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CATTLE AND GRASS ROTATION

Over-population has become serious in certain parts of East Africa, and the resulting over-cultivation and erosion are rapidly approaching a stage at which drastic action will be required in order to prevent widespread famine. The present system of "soil-mining" must be replaced by more intensive farming, and we are back to the age-old problem of how to make two plants grow where only one grew formerly, since in most areas it will be necessary to double the yield per acre in order to allow room for a suitable rotation of crops and stock. Dr. Martin has proved in Uganda that a marked increase in fertility can result from improving the structure of the soil under grass fallow, but he also points out that no amount of resting under grass could be expected to produce crumbs in soils which are low in colloidal clay. On the other hand grass rotation should always improve a soil even if it is too sandy to produce crumbs, since the organic matter added when the grass is ploughed in will act as a sponge for retaining water and plant food. Thus it is almost certain that temporary grass ley will be of value in every part of East Africa, but it must be remembered that grass ley involves planting suitable grass and that the land cannot merely be allowed to lie fallow under weeds and bush. The farmer will want to get some return for his time and trouble in planting grass, apart from the increase in fertility which will show up in subsequent crops.

Animal husbandry is an essential part of more intensive systems of agriculture, for the utilization of the grass ley by grazing or for fodder crops brings in some return during the resting period. Even in areas where the tsetse fly normally prohibits stock-keeping, controlled settlement gives good prospects of successful stock-raising in the middle of large clearings. Whatever the function of stock in a rotational system, whether it is kept for milk or for beef, the cost of upkeep of an animal rises, in terms of human effort if not of cash, whenever it is moved off the open range into a farm rotation. If only ten head can be kept on the farm as compared with fifty on the range, the value of the individual animal will rise in the owner's eyes. The African's present desire to possess as many cattle as he can, irrespective of quality, is easily understood if we look on them as "walking bank-notes". There is the point too that the African could eat his "bank-note" at a pinch, and although its texture may sometimes approach that of its paper equivalent, the nutritive value of the toughest animal is higher than that of the most delicate Bank of England note. On the range hardiness is the first essential, and low-grade stock can exist when more delicate animals could not; on the farm a thriftless animal is a liability rather than an asset.

Overstocking has become so serious in many parts of East Africa that a reduction in the stock population is necessary in order to save the districts from ruin. Although it is not easy to substitute in popular esteem the surreptitious wealth of a credit bank balance for the flamboyant opulence of a hundred head of cattle, yet it is encouraging to know that this change has recently taken place in Uganda, as is shown by the following extract from the Annual Report of the Veterinary Department, Uganda, 1944: "Only a few years ago the popular outcry was that there were too many cattle in Uganda, that overstocking and heavy concentrations were common in the more populated areas and that unless something was done in the way of destocking, irreparable damage to the soil would result. The situation to-day is vastly different. The established and expanding market systems and export facilities provided brought to the African an increasing realization of the value of live stock, in terms of hard cash, to such an extent that it soon became evident that destocking was no longer a problem. On the contrary the increased popularity of the market systems coupled with successful measures of disease control made possible the development of the live stock trade to a degree that began to cause anxiety by early 1943, and despite implementation of protective measures of control, over-selling still continues." Whenever the stock-owner begins to think of his animals in terms of cash he will appreciate the value of improved breeds and better feeding. He will soon see that it does not pay to put good food into a low-grade, thriftless animal, and that it is better to have a small number of good-quality cattle and to feed them well in order to have a quick financial turnover. If milk production is his aim, better feeding will give an immediate increase, and it is interesting that the Veterinary

Department in Uganda did not find it possible to make proper selection of animals for milk production until their feeding had been standardized at a high level. Unless a supplementary ration was fed, the food intake from grazing varied considerably and affected the milk production.

In native agriculture milk production should be a major interest, not merely for sale but also to feed the family. In his 1944 Annual Report the Director of Veterinary Services, Tanganyika, says: "It is a melancholy thought that the nutrition of the natives of the Territory is on such a low plane that only one man in ten was fit enough to pass the very moderate physical standards required by the Army during the present war. It is not too much to say that the provision of increased supplies of milk, meat, and animal fats in the diet of the people should be the first consideration in any post-war development plan". For some years the grading-up of native cattle for milk production has been the chief problem of the animal husbandry sections of the Veterinary Departments of the three East African territories, and sufficient progress has now been made to indicate the lines on which large-scale improvement could be carried out. Imported Zebu bulls are producing progeny which have retained much of the native hardiness while giving more milk. The obvious thought that the milk yield could be greatly increased by introducing high-production breeding stock is also dealt with in the 1944 Tanganyika Veterinary report: "The practice of grading-up local Zebu cattle by the use of imported bulls of European breeds is not likely to produce successful results of a permanent nature throughout the greater part of Tanganyika Territory, though it is possible that with very careful management such stock might be maintained in a few selected areas provided the process is not carried too far."

The dangers attendant on selection or grading-up for milk production in areas liable to drought are brought out in the Kenya Veterinary Report for 1944, a year in which all the breeding centres were affected by drought. "The Ngong herd, which was formerly one of the best, suffered a severe setback from which it will take some years to recover." In contrast, the hardiness of native-owned cattle is emphasized in the Tanganyika Veterinary Report for 1943, in which year there was an unprecedented drought. "It is rather remarkable that on the whole most of the stock manage to survive, and demonstrates once again the wonderful powers of resilience of the local Zebu cattle."

Thus, good as the native cattle may be as foundation stock it is only in areas of reasonably assured rainfall that rapid strides in grading-up could be made. How much can be done in a favourable climate is shown by the 1942 Uganda Veterinary Report, in which it is reported that, at Entebbe "We have after 12 years some 400 acres of well established good permanent pasture capable of supporting approximately one beast to the acre throughout the year." This is rather an extreme example when considering native agriculture, since the working bullocks and cows in milk received supplementary feeding, and, as the report states: "There is obviously an added manurial value in the faeces of cattle fed with these concentrates and by proper management and chain harrowing a richer ground cover and sward should result." Yet it shows what can be done under a reliable rainfall. In Tanganyika, on the other hand, the 1943 Veterinary report states "The conditions which obtained in 1943 show quite clearly the futility of attempting to improve the methods of animal husbandry until some progress can be made in overcoming these recurrent droughts. It is true to say that 1943 was exceptionally bad from this point of view but such misfortunes occur, although to a lesser degree, fairly frequently." The 1940 report gives some idea of the extent of the losses in Tanganyika through drought. "An animal wastage of about 100,000 head of cattle from inanition can be expected to take place in the last quarter of the normal year, but in seasons of poor rainfall this loss has been computed to be in the region of 300,000. Valued at £1 per head it becomes obvious that such preventable wastage (including the loss in the value of the hides and skins) is a severe drain on our territorial resources at any time but under present circumstances it should drive us furiously to think."

While cattle in some parts of East Africa can be improved and are being improved, there are large areas, particularly in Tanganyika, where only the very hardiest of stock can exist, and even the low-grade native cattle "with trailing feet and shambling gait" are better than no cattle at all. In some areas live stock improvement will be limited by lack of water, but wherever better stock can be kept in rotational farming the aim should be to make one good beast grow well where five poor ones merely exist now.

D. W. D.

LAND USE IN THE OVER-POPULATED AREAS OF KABALE, KIGEZI DISTRICT, UGANDA

By J. W. Purseglove, B.Sc., A.I.C.T.A., F.L.S., Agricultural Officer, Uganda Protectorate

Kigezi District is situated in the extreme south-west of Uganda and is bordered by the Belgian Congo on the west and Belgian Ruanda-Urundi on the south. It was one of the last districts in Uganda to come under British rule and the present boundaries were defined by the Anglo-German-Belgian Boundary Commission of 1912. The first Europeans to enter Kigezi were Emin Pasha and Stuhlmann in 1891. Civil administration commenced in 1912 and the district headquarters were moved to the present site at Kabale in 1914.

Seldom is it possible to meet with such varied and beautiful types of country in so small an area as are to be found in Kigezi District with its volcanic peaks of the Birunga Range, of which Mt. Muhavura (13,547 ft.) is the third highest mountain in Uganda; the fertile lava plains of Bufumbira; the broken mountainous country around Kabale; the scattered lakes, of which the sinuous Lake Bunyonyi is particularly beautiful; the forest-clad slopes of the Impenetrable Forest; the rolling grasslands of Ruzhumbura and the arid Lake Edward plains which are the home of much big game.

The Over-populated Areas—General Description

During recent years there has been a very considerable increase in the population living in the mountainous country within a 12 miles radius of Kabale, with the result that much of this area is now over-populated. Early in 1945 the writer investigated and reported upon the problems involved (Purseglove, 1945), some of which form the subject of this article.

Topography.—The over-populated areas consist of four main ridges with summits of 7,000 to 8,500 ft. and three main valleys, the floors of which for the most part exceed 6,000 ft., all running from south-east to north-west. They are broken by short, steep-sided dip valleys separated by fluted spurs of the Karagwe-Ankolean hills and with numerous subsidiary strike valleys. The narrower, higher valleys are usually dry, but the lower, wider, valleys contain papyrus swamps, sometimes over a mile in width.

Climate.—The area lies in a zone of low average rainfall. There is a marked dry season from June to August and a lesser one from December to February. The average annual rainfall at Kabale (6,139 ft.) for the past 28 years is 39.22 inches and the average monthly rainfall is shown in the following diagram:—

Kabale Rainfall, 1918 to 1945 (in inches)
Average for 28 years = 39·22 in.

The annual rainfall shows wide fluctuation as is shown by the fact that, during the past ten years, the maximum was 58.49 inches and the minimum 30.56 inches, with a variation between two consecutive years of 20 inches. The low rainfall intensity is a most important factor in the prevention of serious erosion. Storms of over 1 inch of rain in 24 hours are very infrequent. Thick morning mists are a characteristic feature of the climate and the average humidity at 8.30 a.m. is 91 per cent. Kabale has a mean temperature of 61.3°F. with an absolute minimum of 41.0°F. and an absolute maximum of 87.5°F. Walter (1940) states that "the approximate number of hours a day on the average below 64°F. is 13."

Soils.—The rocks of this mountainous overcrowded area are metamorphosed lake sediments of the Karagwe-Ankolean system of

shales, phyllites, quartzites and sandstones. They are of great thickness and have been considerably distorted, dipping at steep angles. The softer members of the series have produced a deep fertile soil of good structure, not easily erodible and of good lasting power. The reddish-brown loams, which are the most heavily cultivated, are found on the hill-slopes, except where these are very steep, and are deepest in the hollows in the hill-folds and along the foot-slopes. Tests by Dr. Martin (1945) showed that the mean pH of 24 samples for the Kabale area was 6.7, "an indication that the soils are well supplied with bases". Dr. Martin also examined their crumb structure by the method described by him (Martin, 1944) and found that the percentage of crumbs greater than ½ mm. was very high, even in plots which have been cultivated for many years. He considers that this is "the probable explanation of the extreme permeability and resistance to erosion of the Kabale soils".

The soils of the very steep slopes are thin and stony with numerous outcrops of the parent rock and can only be used for rough grazing. The hill-top soils are usually shallow, containing unweathered rock fragments, and do not produce such good crops as the gentler slopes. In the past the hill-tops were used almost entirely for grazing, but the pressure of population has resulted in much of this land now being cultivated. The valley floors have a heavy grey loam, rather acid and intractable in wet weather.

The Inhabitants.—The inhabitants of the over-populated area are Bakiga, an industrious, grain-eating, Bantu tribe, who migrated here several generations ago from Ruanda. They build their houses in the valleys and on the lower slopes and cultivate up the hills. In the past, before the present pressure of population, there was always more land further up the hill, but now cultivation has reached the summits of most of the ridges and much of the grazing land on the thinner soils has come under the hoe.

Land Tenure.—All land in Kigezi, with the exception of the Mission plots, is Crown land. Originally a man owned as much land as he could cultivate and defend with the assistance of his clansmen. With the establishment of a settled administration, this became modified to the principle that a man has the usufruct of as much land as he can cultivate in a year, together with the fallow land which he can prove he has cultivated for at least seven years previously. There exists an absolute security of tenure to the peasant cultivator and his heirs and he can rent, will or sell this usufruct of his land. With the present land shortage, the definition of ownership is very clearly demarcated and all disputes are taken to the native courts if they cannot be settled without litigation. Any surplus land is allocated by the chiefs. Usually a man has several blocks of land, as he recognizes the different soils most suitable for his various crops. As a man's family increases he needs more land and people are now having to go much further afield to get this and he will now endeavour to borrow, rent or buy additional plots. This, together with the system of inheritance, has resulted in much fragmentation of holdings and plots may be long distances from the homestead. In certain areas he will have to move away completely to new areas as he cannot obtain sufficient land locally. All grazing land is used communally.

Native Agriculture.—The staple food of the Bakiga is sorghum, which is also extensively used for brewing beer. Peas and beans form an important part of their diet, as do sweet potatoes, the cultivation of which is fairly recent. English potatoes became very popular, maturing more quickly than sweet potatoes and giving high yields, but their cultivation has now almost ceased due to severe blight attack. Finger millet (Eleusine) is grown almost entirely as a famine reserve. Plantains do not do well in the Kabale area; their acreage is small and they are generally of the beer varieties. The Bakiga have no crops rich in oil, with the result that their present diet is very lacking in fats. The main planting and harvesting seasons are given in Table I.

TABLE I—SEASONS OF THE PRINCIPAL CROPS

Crop	Planted	Harvested
Sorghum	Dec. and Jan.	June and July
Eleusine ..	Sept. and Oct.	Feb. and March
Peas	Sept. and April	Jan. and August.
Beans	May and Sept.	August and Dec.
Maize	August and Sept.	Jan. and Feb.
Sweet potatoes..	All the year round	After 6 months.

The bulk of the work on food cultivation is done by the women, using a short-handle hoe, but men may assist in all operations except weeding. Most of the initial clearing is done by the men. Cattle, sheep and goats are kept but only in small numbers.

The two main sources of income are labour and the sale of food, although since 1941 very considerable sums of money have been brought into the district by people serving with the Army. The labourers from Kigezi work either in the mines or in Buganda, but a fair number of people find temporary local employment. Prior to the ban on the exportation of foodstuffs from the district in January, 1943, some cultivators sold their surplus food (peas, beans, English potatoes, sorghum and wheat) for export outside the district, whilst there was a large trade in the export of food to Ruanda in exchange for goats. In addition there was, and still is, a very considerable internal trade in beer and to a lesser extent in food.

Any economic crop grown in Kigezi must be of relatively high value to stand the long haul to the railhead. So far only three crops of this category have been found. Arabica coffee at first showed promise and 339 tons were exported from the district in 1942. Growers became discouraged by the serious ravages of the *Antestia* bug and production dropped to 38 tons last year. Experiments for the control of *Antestia* by locally-produced pyrethrum have been started. High nicotine content tobacco has been successful and there is at present an increasing and large demand. A factory for the extraction of nicotine has been built by private enterprise near Kabale. Two crops per year are grown, with a total acreage of 968 acres during 1945, and average yields per acre were over 600 lb. This crop is produced mainly in the area round Kabale. A flax industry was started in 1942, but only a very small proportion of the 1,000 acres grown annually is planted in the over-populated areas. Bees-wax is produced on a small scale.

Population Statistics

A study of the population statistics indicates how the over-population has been brought about. Of the total population of Kigezi District, 33.6 per cent live in the 234 square miles around Kabale. The population density of this area in 1943 was 359.8 people per square mile whilst one area of the densest population had 717.9 people per square mile. A study of the poll tax statistics of the over-populated areas shows that there was a 59.6 per cent increase in the number of taxpayers during the 12 years, 1932–43. This increase was due to two factors, (1) immigration from Ruanda and elsewhere, 26.4 per cent, (2) natural increase due to the high birth-rate, 32.2 per cent. Of the total immigrants 74.7 per cent came from Ruanda. Immigration from Ruanda or the Congo to any part of Kigezi was stopped in 1943. It is estimated that the population will double itself in 30 years by natural increase alone, so even if immigration had been forbidden for a much longer period, it is inevitable that the present state of overcrowding would have resulted in the near future. The comparative absence of venereal disease and malaria, the custom of marrying when young and the practice of polygamy are the main factors in promoting the high birth-rate.

In the area with 717.9 people per square mile there is only 4.45 acres (0.891 acres per head of population) of living space per taxpayer in which to have his house, grow crops for himself and his family and possibly some for sale, graze a cow and five sheep or goats, grow trees for building and fuel, and allow for some land which is uncultivable, either stony hillside or swamp. The average acreage of cultivable land per taxpayer in this area as ascertained by a survey in 1936 was 10.5 acres as compared with less than 4.45 in 1943.

The Traverses

It was essential to find some quick method of survey to ascertain whether the land was over-cultivated and to obtain an estimate of land use in the over-populated areas. It would have taken too long in the time at my disposal to survey a number of *mitala* (village hundreds), which was the principal method of agricultural survey carried out in Uganda in the past. (Tothill *et al.* 1938.) In any case such surveys would not give a true index of land use in this area as a cultivator's holding is usually spread over a number of *mitala*. The method adopted in the present survey is one which I believe to be new to agriculture survey and is primarily based on the line transect of the plant ecologist and which is the basis of the method of forest survey called "Linientaxirung" used by the German foresters. (Tansley and Chipp, 1926.)

Starting from a random point in the area to be surveyed, lines were marked on a 1:50,000 map at 1½ mile intervals using a road as a base line. The majority of the lines or traverses ran due north-east so as to cut across the topography, the mountain ridges in the area running north-west, thus giving a fair proportion of swamp, valley, hillside and hilltop in each of the traverses, and were usually at right-angles to the plot lengths. Then from the fixed points the bearing was taken with a 4-inch

prismatic compass and every foot along the line was measured with a 100 ft. chain, recording the use to which the land was put, e.g. cultivated land and name of growing crop, resting land and period of resting, grazing, cultivable and uncultivable, swamp, tree plantations, house compounds, etc. The traverses were continued for 2–4 miles regardless of the terrain of the country, usually to a road running in the further valley. Thus a complete analysis of land use along each traverse was obtained and, provided sufficient traverses are done, this should be fully representative of the whole countryside where similar conditions prevail. There was no difficulty in completing a 3-mile traverse in one day.

In addition to the linear measure, the angle of all slopes was recorded, using an Abney level, as the degree of slope is of the utmost importance in mountainous country such as this for deciding whether the land should be cultivated and as a factor in the erodibility of the soil. Information on the condition of the anti-erosion measures and the types of soil and parent rock was also recorded.

In all 32.8 miles of traverses were measured in the over-populated areas and a further 4.2 miles in areas not over-populated, for comparison. As the position of the traverses can be fixed accurately on the map, they can be repeated whenever it is desired. The traverses should be measured, if possible, at the end of the main planting season, and if they are done in the spring and autumn a full picture of land use can be obtained. The method can be used in any type of country, but it is obviously simpler in short-grass areas where the lines along the compass bearings can be easily and quickly marked out.

The Sample Households

At every mile along the traverses the name of the owner of the plot, or nearest plot to this point, was noted. His homestead was later visited and all his plots, cultivated or resting wherever they might be, his house compound and tree plantations were measured. The number of wives, children, taxpayers, and live stock was recorded at each of the sample households, as well as economic and sociological data. Thus, much information was acquired on individual holdings, some of which can be correlated with that obtained from the traverses. The two methods are complementary and it is considered that both should be done if complete details on land utilization are required. Thus the sample households give specific information on the land use by individual households, taxpayers or whatever unit of population desired, in addition to supplying much other data, whereas the traverses supply information on land utilization as a percentage figure for an area as a whole.

A very close correlation was shown between the percentage cultivation of the various crops as obtained from the traverses and the sample households and is given in Table II.

Table II

Percentage Cultivation of the Various Crops

Crops	Traverses	Sample households
	Per cent	*Per cent*
Sorghum and maize, alone or with other crops	54·2	54·8
Sweet potatoes	16·9	17·2
Eleusine	13·1	13·3
Peas	10·9	10·4
Plantains	2·8	2·5
Miscellaneous crops	2·1	1·8

Sorghum and maize plots have been grouped together as some of the maize plots measured in the January traverses had been planted with sorghum before the completion of the survey of the sample households. Beans do not appear in the above list as there were very few beans in the plots at the time of the surveys and they were usually interplanted with the maize. This close correlation provides most gratifying evidence of the accuracy of the present method of survey.

Land Use as Shown by the Traverses

The analysis of land use as obtained from the traverses is given in Table III.

Table III

Analysis of Land Use as Percentages of the Total Traverses, Excluding Swamps

	0-15° slope	Over 15°-20° slope	Over 20° slope	Total
	Per cent	*Per cent*	*Per cent*	*Per cent*
Total cultivation ..	41·7	8·5	5·4	55·6
Total resting land ..	13·0	4·5	2·9	20·4
Permanent grazing ..	4·3	3·1	9·5	16·9
Tree plantations ..	2·2	0·4	1·4	4·0
House compounds ..	1·5	0·3	0·1	1·9
Bush	0·3	—	0·9	1·2
Total traverses, excluding swamps ..	63·0	16·8	20·2	100·0
Cultivable land—(0-20°)	57·5	13·9	—	71·4
Uncultivable land ..	5·5	2·9	20·2	28·6

I now propose to comment on the results and the conclusions which may be drawn from them.

Swamps.—Swamps or marshy ground occupied 9 per cent of the total land surface. Large swamps were measured from 1:50,000 maps, but small swamps and marshy ground crossed by the traverses were measured by chain. Of the total swamp area, 5.5 per cent was growing sweet potatoes; 8.8 per cent was resting, having previously grown crops; 4.3 per cent was under trees, mainly Eucalyptus; 3.5 per cent was cultivable with slight drainage; while 77.9 per cent was uncultivable unless large-scale drainage projects can be undertaken. It is obvious that if the swamps can be drained successfully much extra land would be available for cultivation, but the whole question of swamp reclamation is one of great complexity and much more information is required on the effect of drainage on local climate, water tables, etc., before intensive reclamation can be safely begun. Work on this aspect of the problem is now being undertaken. Small areas have been drained successfully and have produced good food crops and excellent planted pastures. In some areas sweet potatoes were grown on the swamp fringes without adequate drainage and while they constituted an excellent food reserve during the droughts of 1943–44, they formed breeding places for mosquitoes of the species *Anopheles Christyi,* which was found to be a vector of malaria. In this respect it was found that untouched swamps and properly drained swamps with clean, freely flowing channels were comparatively harmless while undrained swamp cultivation with water lying between raised beds was very dangerous. In the subsequent analysis of land use I have excluded swamps (and in Table III) as they present such special problems.

Angle of Slope.—The total land traversed, excluding swamps, can be divided into three categories.

(1) 0°–15°. Of the land area 63 per cent was on these slopes which includes the most generally cultivated land. Under local conditions it is not dangerous from the point of view of erosion, provided soil conservation measures are employed.

(2) Over 15°–20°. These slopes comprised 16.8 per cent of the land area and they can be cultivated when the soil is of reasonable fertility, but careful soil conservation methods must be used if the soil is to remain in situ.

(3) Over 20°. 20.2 per cent of the land was on these steep slopes. Such land is usually reserved for grazing but with the pressure of population a quarter of it was growing crops and about a half of it only was reserved as permanent grazing. I do not consider that any land on slopes as steep as this should be cultivated unless it is terraced. Even land with a 35° slope was being cultivated and some grazing land had a slope of 45°. The steeper the slope the more frequent and longer was the resting period, showing that the fertility of the soil is less and erosion more rapid on the steeper slopes, which of course, is what one would expect.

Cultivated Land.—Of the total land area excluding swamps 55.6 per cent was under cultivation at the time the traverses were measured. If we regard all land with slopes of up to 20° as cultivable and exclude paths, house compounds, trees and swamps, 71.4 per cent of the land surface can be cultivated. Of the total cultivable land 70.4 per cent was under cultivation, and if we retire from cultivation all land on slopes of over 20° at present cultivated, this figure would be increased to 77.7 per cent. The percentage cultivation of the various crops is given in Table II.

Resting or Fallow Land.—It was surprisingly difficult to obtain accurate information from cultivators as to the length of time which their plots had been cultivated or rested. Furthermore, cultivators were not often present on their plots crossed by the traverses. The plant succession on the resting land was worked out so that the period for which the land had been rested could be quickly recorded.

The periods for which the fallow plots had rested is given in Table IV and is expressed as a percentage of the land under cultivation and growing crops.

TABLE IV

RESTING LAND EXPRESSED AS PERCENTAGES OF CULTIVATED LAND

Period of resting	Total in traverses	In traverses on slopes 0-20°	Total in sample households
	Per cent	*Per cent*	*Per cent*
Rested for 6 months or less	19·0	17·1	18·0
Rested for 1 year ..	10·8	9·0	12·9
Rested for 1½ to 2 years	5·0	3·7	9·4
Rested 3 years or more	1·8	1·5	—
Total resting land..	36·6	31·3	40·3

For every three plots cultivated there was approximately one plot resting, and the majority of the plots had been rested for short periods only. Of the total resting land 51.7 per cent had rested for six months only.

The crux of the whole problem as to whether the over-populated areas can continue to support the present population is the period for which the land can be cultivated without causing serious soil deterioration and the period for which the land must be rested to restore fertility before again being cultivated. Crops still give fair yields despite over-cultivation and soil erosion is not yet a serious problem. Most cultivators are emphatic, however, that over-cultivation has resulted in a reduction in crop yields. This is particularly noticeable in years of low rainfall when neighbouring areas, as yet not over-populated, give far bigger yields than the Kabale area, although they have the same type of soil and receive the same rainfall. Dr. Martin's (1945) analysis of crumb structure of the Kabale soils shows that if the optimum crumb structure may be taken as those areas which have always been used for grazing, deterioration through cultivation has occurred. While one would like to know much more about the many factors involved, I consider that it would be very unwise to continue with the present system in which the resting period is very brief and in some cases absent, and recommend that cultivable land be reorganized on strip-cropping lines with the land being cultivated for four years and rested for two, preferably under a grass ley. Also that land on slopes of over 20° be retired from cultivation. In order to do this 25 per cent additional cultivable land would be required. In other words, it would be necessary to move 25 per cent of the present population or approximately 14,500 people. This is the theoretical minimum number.

Grazing.—Land reserved almost entirely for grazing occupied 16.9 per cent of the total land surface, excluding swamps. Of this percentage, 9.5 per cent was on very steep slopes of over 20°, where the soils were thin and rocky outcrops frequent. 3.4 per cent was permanent pasture on land suitable for cultivation, usually situated in the valleys, and was used mainly as dry-season grazing. If this could be replaced by swamp pasture, this valuable acreage could be released for cultivation. At present, resting land is seldom grazed because, with the existing patch-work system of cultivation, it is difficult to get the cattle on to the resting plots without causing damage to standing crops. If true strip-cropping could be obtained, the resting strips could be used for grazing and would be easily accessible from the cattle paths. Furthermore, the stock could thus be used to build up the fertility of the resting land, as with the present scattered holdings it is impracticable to head-load the manure the long distances from kraal to plots. Also grazing of the stubbles results in the grasses, mainly *Pennisetum clandestinum* and *Cynodon plectostachyum*, appearing much earlier than in the present succession, with the result that a grass ley is more quickly formed. Apparently, passage of grass seeds through the alimentary tract of stock results in accelerated germination. The cattle paths up steep ridges are at present a serious cause of erosion and it is recommended that they be hedged and duplicate cattle paths be established which can be used rotationally.

A study of the statistics of the taxpaying and stock population of the over-populated areas shows that the average stock per taxpayer is 1.05 cattle, 2.81 goats and 2.63 sheep. If grazing were limited to the permanent pasture, these would have to carry 0.766 cattle, 2.05 goats and 1.89 sheep per acre.

Tree Plantations, Bush and House Compounds.—The Bakiga, who prefer to live on the fertile foot-slopes, usually plant their trees near their houses. They are thus near at hand and thieving is prevented. Trees occupied 4 per cent of the total land area excluding swamps, and of this, 2.6 per cent was on good agricultural land. If tree planting were confined to the steep slopes with poor soil, this 2.6 per cent would be released for cultivation. The majority of the trees planted are black wattle.

As would be expected in over-populated country most of the bush has now been cleared. It occupied only 1.2 per cent of the land area and was mainly uncultivable. Apart from the planted trees, woody vegetation is scarce with a resultant scarcity of firewood. House compounds occupied 1.9 per cent of the total area, excluding swamps.

Information Obtained from the Sample Households

For the purpose of this investigation a household was taken as the family of people who live in the group of houses surrounding a single compound. It is essentially a family unit and may include married sons and their families, as well as their parents, other children and dependants. Sons may move away from their

father's kraal at marriage and build their own kraal nearby, but with the present acute shortage of land some have had to move away completely to new areas where land is available.

Human Statistics.—The size of individual households varied from 2 to 45 persons, and one old man had had eight wives and had 31 living children, of whom five wives and 19 children were resident in the household. The average number of residents per household was 13.882 and the ratio of taxpayers to total population was 1:6.051. The average number of living wives per taxpayer was 1.487 and children 4.192, while the average per married man was 1.853 and 4.853 respectively. The average number of surviving children per wife was 2.538 or 2.845 per living wife. 33.9 per cent of the resident population were under ten years of age.

Cultivation Statistics.—The average size of all plots was 0.216 acres. The percentage cultivation of the various crops is given in Table II and the average acreage of cultivation for the various family units is given in Table V.

TABLE V

ACREAGE UNDER CULTIVATION PER VARIOUS FAMILY UNIT

Average acreage per household	7·034 acres
,, ,, ,, taxpayer	2·861 ,,
,, ,, ,, resident person ..	0·473 ,,
,, ,, ,, wife	1·924 ,,
,, ,, ,, work unit	0·815 ,,

The closest correlation between acreage cultivated and any particular unit of the family was given by the acreage per resident person, whilst the greatest divergence was shown by the acreage per taxpayer. As little food is bought by the household, the number of people fed must bear a close relationship to the acreage cultivated, whilst the acreage per taxpayer will depend on the number of people in his family and this is very variable. The acreage per wife, who after all does most of the cultivation, was fairly constant, as was the acreage per work unit. It is always a vexed question as to what shall constitute a work unit. In the present survey I have taken every resident member of the household over ten years of age as one work unit, excluding very old people and members who work outside the household for wages.

Resting or Fallow Land.—The average acreage of resting land per taxpayer was 0.951 acres. Excluded from this figure is land on very steep slopes which had rested for long periods and was grazed at the time of the survey, and which was recorded in the traverses as uncultivable grazing. 28.8 per cent of the cultivable land was resting and the total resting land given as a percentage of the land growing crops was 40.3 per cent. The percentage of fallow land for the various periods of resting is given in Table IV and shows a close correlation with that of the traverses. If land is to be cultivated for four years and rested for two, 52 per cent of the sample households had insufficient land to do this.

Live Stock.—The average head of stock per taxpayer was 1.089 cattle, 2.192 sheep, 3.013 goats and 2.692 fowls. 155 beehives belonged to people of the households selected at random, and of these 59 contained bees.

Tree Plantations and House Compounds.—The average acreage of tree plantation per taxpayer was 0.273 acres, which generally produced an adequate supply of poles for building purposes. Approximately half the households obtained their firewood from their black wattle plantations, but the remainder used mainly papyrus rhizomes, eked out by scanty brushwood and sorghum and maize straw and stubble.

The average size of house compound was 0.190 acres or 0.101 acres per taxpayer. They were usually strongly fenced with live hedges.

Income.—Approximately half of the sample households derived the whole of their income from the land, usually by the sale of beer and food. Very few grew the economic crops, nicotine tobacco and coffee, which occupied only 1.1 per cent of the cultivated land in the traverses. Most of the other households obtained their income by temporary local employment. The monetary requirements of the average taxpayer are small, the main item being Sh. 13 per year in direct taxation. He requires a little money to buy hoes, salt, etc., but little is spent on clothes, as goat skins are still the principal article of dress. The largest item of expenditure is at times of marriage.

Other Information.—Permanent water was seldom more than a quarter of a mile from the households and was often much nearer. The over-populated areas are well-watered and there is no tendency to cause congestion round the water supplies. Holdings are very fragmented, usually with a few plots in the vicinity of the homestead and the remainder a half to one mile away. In one case the distance was as much as five miles. This has been brought about largely by the overcrowding. Meat was seldom eaten regularly, often only once or twice per year.

Conclusions

With the present high natural increase in the population it is obvious that there will soon be insufficient land in the Kabale area to support all the people, even if some intensive system of agriculture could be devised which would obviate the necessity of resting land. Some people have already moved from the over-populated areas and others will have to move because they have insufficient land under the present conditions. It has been shown that there has been some deterioration of the soil through over-cultivation and I do not believe that the present system can be continued indefinitely without cumulative serious results. It is suggested that the land should be reorganized on strip-cropping lines with one strip in three resting and that cultivation on the very steep slopes of over 20° should cease. To do this I have shown that the theoretical number of people who would have to move is 25 per cent of the present population; in practice it would probably be necessary to move one-third or approximately 20,000 people. New and suitable areas have been found to which the people can move. In the absence of serious erosion, it is recommended that the width of strip should be 16 yards on slopes of 0°–15° and 12 yards on 15°–20° slopes. Once this system of strip-cropping has been established, automatic control of the number of people on the land will have been accomplished. Everything should be done to improve the yield per acre of all crops by manuring and selection of improved varieties. Work on these lines has already commenced. Finally I envisage the evolution of a permanent system of husbandry, but before this can be done intensive organized research and survey are necessary, with the object of working out the ecological interpretation of the country and its mode of life. Most progress will be made by the grafting of improved methods on to the existing system rather than by the introduction of completely novel methods. The improvement, and in the final instance, the saving of the soil is, and must be, the basis of all agricultural prosperity. I feel very strongly that definite action must not long be delayed if the fertility is to be maintained and the prosperity established of the beautiful country round Kabale.

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When the moon shall have faded out from the sky and the sun shall shine at noonday a dull cherry red, and the seas shall be frozen over, and the ice cap shall have crept downward to the Equator from either pole, and no keels shall cut the waters, nor wheels turn in mills, when all cities shall have long been dead and crumbled into dust, and all life shall be on the verge of extinction on this globe—then, on a bit of lichen, growing on the bald rocks besides the eternal snows of Panama, shall be seated a tiny insect, preening its antennae in the glow of the wornout sun, representing the sole survival of animal life on this our earth, a melancholy "bug".

Dr. W. J. Holland, quoted in
General Entomology (S. W. Frost)

It is difficult to conceive anything more scientifically bigoted than to postulate that all possible experience conforms to the same type as that with which we are already familiar, and therefore to demand that explanations use only elements familiar in everyday experience. Such an attitude bespeaks an unimaginativeness, a mental obtuseness and obstinacy which might be expected to have exhausted their pragmatic justification at a lower plane of mental activity.

Prof. P. W. Bridgman, in
The Logic of Modern Physics.

N.B.—We reproduce this for the excellence of the sentiment, not as a model of good writing.—*Ed.*

SOME ASPECTS OF INSECT PARASITES AND PREDATORS

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This article is intended to be interesting rather than of practical utility. Every farmer knows of the enormous value of entomophagous (i.e. feeding on insects) insects and that, without them, the plant-feeding insects would increase so rapidly that within a very few years nearly all crops and indeed most other vegetation would disappear from the surface of this planet. But probably few realize the diversity of the methods of attack that have been evolved by insects against other species of their order. For it may be remarked in passing that insects, in common with all other animals except *Homo sapiens*, never wage war against their own species. They may occasionally turn cannibals under the stress of famine, and sometimes they kill each other under the dictates of sex, but it is only the Lord of Creation who indulges in organized destruction of his own kind.

Entomophagous insects are usually divided into predators and parasites, though the distinction is really an arbitrary one, and there are several border-line cases some of which will be described later. (In the following definitions, nearly all the statements should be qualified by "usually", owing to the number of exceptions from the general rules, but for clarity this qualification has been omitted.)

Predators kill their prey by direct attack; they are of greater size than their victims, of which they consume a number during their lifetime. Often the adult predator feeds on the same sort of food as its larva. Between meals a predator may not necessarily live in the same habitat as its prey; such predators are active insects. Predators tend to have long life-cycles, especially those whose food supply is fortuitous.

A parasite, in the generally accepted medical sense of the word, is an organism that lives, either permanently or temporarily, in or on its host, which is usually very much larger than the parasite. The host has developed some degree of tolerance to the parasite and though it may be inconvenienced is not directly killed by it. A number of insects are parasites in this sense, usually on vertebrate animals. The Mallophaga (bird-lice), the Siphunculata (the sucking lice of man and other mammals), Cimicidae (bed-bugs), Aphaniptera (fleas) and several families of Diptera are the best known of them. But according to this definition there are not many insect parasites of insects. The Strepsiptera are true parasites and so is a queer little wingless Dipteron, *Braula*, the "bee-louse." And though I only know of a single example, which will be mentioned later, there may be a few cases among the Hymenoptera of true parasitism in the above sense.

But the great majority of insects that are parasitic on other insects develop as larvae in or on a single individual of their host, which must therefore be a larger insect, though often not much larger; their attack results in the death of the host, but not until the parasite has completed its development.

The adult parasite is nearly always a free-living insect with food habits entirely different from those of the larva and except for the purpose of egg-laying has no association with its host.

The term "parasitoid" is sometimes used for "fatal" parasites of this type, but the distinction is again a somewhat arbitrary one, for, as will be described later, there is a Hymenopteron that attacks the *Helopeltis* bug, which is a fatal parasitoid when it develops in the earlier stages of its host and a non-fatal parasite when it develops in the later stages. The Strepsiptera, also, do not usually kill their hosts, but sometimes, when too large a number develop in a single host individual, they may do so. Short of introducing a further complication in the shape of the term "non-fatal parasitoid" to cover such cases as the above, it seems preferable to class as parasites all entomophagous insects that are not predators.

Certain other definitions may conveniently be given here. A primary parasite, or often simply the unqualified word parasite, means one that attacks its host directly. If it lives externally and feeds by puncturing the host's body, it is an ectoparasite; if it lives within the body of the host, it is an endoparasite. A secondary parasite, or hyperparasite, is one that lives on a primary parasite. A hyperparasite of a noxious insect is therefore itself noxious, though this general statement is qualified by the fact that there exist insects that are primary parasites of some hosts and secondary parasites of others. The same parasite may

even vary in this respect in different districts. Tertiary parasites certainly exist, and the occurrence of quaternary and even quinquenary parasites has been alleged.

A parasite is monophagous if it is restricted to a single species of host. Although strictly monophagous parasites are not uncommon, increased knowledge shows that they are less numerous than was at one time supposed. On the other hand many are oligophagous, that is to say they are restricted to a single genus, or family, or order, or hosts. Some are polyphagous, attacking a wide range of hosts belonging to different orders.

Multiparasitism is the attack by two or more different species of primary parasites on one individual host. Sometimes this involves the death of one of them—not necessarily the last to attack the host; quite often both are able to survive; and a few instances are known when multiparasitism causes the death of all the parasites, presumably because the food supply in inadequate.

Superparasitism is the attack by more than one individual of the same species of parasite on one host individual. This is often a normal occurrence and many hundred chalcids may develop successfully within a single larva of a moth. Where it is not normal, the female parasite often seems able to recognize an already parasitized host and avoids laying eggs in it; but this instinct occasionally fails, with the result that sometimes only one parasite survives and sometimes the host dies prematurely, involving the death of all the contained parasites.

Of the twenty-three orders of insects according to the widely accepted classification of Imms, the predatory habit has developed in at least some families of no fewer than sixteen orders. Parasites in the entomological sense as defined above are found in five orders (of which four also contain predators) and parasites in the medical sense in four orders, two of which also contain predators and one "entomological" parasites as well. There are thus only four orders in which the entomophagous habit has not developed at all, and only one of these, the Isoptera (termites) is an order of any importance.

It may, therefore, be of interest firstly to give a brief indication of the extent to which predatism or parasitism occurs in each order and secondly to give a short account of some of the more interesting types of predators and parasites.

THE PREVALENCE OF ENTOMOPHAGOUS HABITS

Thysanura (silverfish).—The predatory habit is occasional only; one species is known to feed on the eggs and young nymphs of termites.

Protura.—A very small order of obscure, little-known insects. None of them is likely to be carnivorous.

Collembola (springtails). — Also a small order, though some species are abundant in individuals, containing neither parasites nor predators.

Orthoptera (locusts, grasshoppers, stick insects, praying mantids, cockroaches, crickets).—The Mantidae are invariably predacious both as nymphs and adults. A few species of long-horned grasshoppers and crickets have also developed the habit, but in general the members of all the other families are plant or refuse feeders. One species of long-horned grasshopper has been observed to attack nymphs of the red locust in Nyasaland.

Dermaptera (earwigs).—These are generally regarded as plant pests, but a few species also live, at any rate partly, on insects. The common European earwig feeds frequently on fleas, and another species is of considerable value in Egypt in destroying the caterpillars of the moth known as the cotton worm.

Plecoptera (stone flies).—This is a small order, the nymphs of which live in streams. Most of them feed on aquatic vegetation, but in one family (Perlidae) they are mainly carnivorous.

Isoptera (termites).—This is the only important order that is entirely non-parasitic and non-predatory. There are many species of termites that live permanently within the nests constructed by other species but their relationship appears to be a friendly one, and the occurrence of social parasitism (*see* "Social Parasites", below) is not proved.

Embioptera.—A very small order of insects that are seldom seen. Little is known about their feeding habits, but although the females probably live on plants the males are believed, because of the entirely different structure of their mandibles, to be carnivorous.

Psocoptera.—Several species of one family (Caeciliidae) have been recorded in Kenya as predacious on the coffee mealy bug. At one time it was thought that they were very valuable predators of this pest but although they will, in captivity, feed on small living mealy bugs, it is probable that their normal food is dead mealy bugs and their waxy secretions. Their reputation was probably based on the rapidity with which they cleaned up a coffee

plantation after a bad attack of mealy bug, removing all traces of the infestation, although actually the mealy bugs had been destroyed by other predators.

Anopleura.—All species are external parasites in the "medical" sense. The Mallophaga (biting lice) live mainly on birds (a few species on mammals) and the Siphunculata (sucking lice) entirely on man and other mammals.

Ephemeroptera (mayflies).—Adult mayflies do not feed, and the nymphs are certainly for the most part phytophagous. A few exceptional ones are thought to be carnivorous, but this has not been confirmed.

Odonata (dragon-flies).—Both the nymphs and adults of all species are predacious. Since the nymphs are aquatic they obviously live on different sorts of insects from the adults, and in fact they do not, like the adults, confine themselves to insects but also attack crustaceans, tadpoles and even small fish.

Thysanoptera (thrips).—Although usually known as plant pests, there are many species that either partly or entirely feed on other insects. They tend, more than most other predators, to prey on smaller members of their own order.

Hemiptera (bugs).—Although for the most part plant-feeders, several species in many families have developed the predatory habit and in two families (Reduviidae and Phymatidae) it is universal. There is a Pentatomid (shield-bug) which is a valuable predator of the notorious Colorado potato beetle, and another species, in Europe, has the curious but commendable habit of destroying bed bugs. Several species of shield bugs have been recorded in East Africa as destroying the larvae of various moth pests. *Geocoris*, a bug of the family Lygaeidae, occasionally preys on the coffee capsid bug in Kenya, while a few species of Capsidae destroy mealy bugs and aphids.

The bed-bugs (Cimicidae) are true external parasites of mammals and birds. Several of the water-bugs are predacious, living on fish, tadpoles, etc., as well as on insects. The giant water-bug, *Belostoma*, of which some East African species are about 2 in. in length, can inflict a most painful puncture, especially on one's toes.

No species of the sub-order Homoptera is carnivorous: although the common cotton jassid not infrequently bites man it is doubtful if it actually sucks his blood.

Neuroptera (ant-lions, lace-wings and related types).—The larvae of all species of this order are predacious; the adults of some families are also known to be, but many appear to take no food at all. The Mantispidae are in many ways intermediate in habits between predators and parasites. The adults, which have powerful raptorial forelegs very similar to those of the Mantidae, are ordinary predators. The larvae, which in their first stage are very active, seek for and enter the egg-masses of certain species of spiders, only one larva attacking each egg-mass. They prey on the young spiders as they hatch, and subsequently pupate within the egg-mass.

Mecoptera (scorpion flies).—Both larvae and adults of nearly all species of this small and unimportant order are predacious, though the larvae of some may feed mainly on dead or dying insects.

Trichoptera (caddis flies).—The aquatic case-bearing larvae of the majority of species of this order are well known: these are all vegetable feeders. Some species, however, are carnivorous: these make a fixed silken retreat with a miniature fish-net near it, in which small insects and other organisms are snared. The adults of all Trichoptera, if they feed at all, suck the nectar of flowers.

Lepidoptera (butterflies and moths).—None of the adults of this large order, and only a few of the larvae, are carnivorous. A number of families, however, contain a few species with predacious larvae. Among the butterflies this only occurs in the Lycaenidae ("blues"). *Eublemma*, a noctuid, is a not unimportant enemy of scale insects and mealy bugs in East Africa. Two small families of moths have parasitic larvae: although of no economic importance their habits are of such interest that they will be referred to later.

Coleoptera (beetles).—This is the largest order of insects: about a quarter of a million species have been described, and the total existing number may be more than a million. A large number of species in many families are predacious both as larvae and adults: from the economic view-point the Coccinellidae (lady-birds) and Carabidae (ground-beetles) are probably of most importance. Although only a few beetles have adopted the parasitic mode of life, the life history of some of these is of great interest.

Strepsiptera.—This is a small order (which possibly should be considered as aberrant Coleoptera) of little-known insects that are seldom seen, even by entomologists, unless

specially sought for. They are without exception internal parasites, mainly of Hymenoptera and Hemiptera: certain aspects of their remarkable life-history will be mentioned later.

Hymenoptera (saw-flies, ichneumon-flies, ants, bees, wasps, etc.).—The great majority of this large order (nearly 100,000 known species) have entomophagous habits. The only important groups that are phytophagous are the saw-flies and bees (but by no means all of these), the fig insects and gall wasps, and some seed-eating Chalcids. Among the remainder parasites are dominant but a number of families contain predators only and several include both parasites and predators.

As would be expected in such a large and mainly carnivorous order almost every type of parasitism occurs.

Diptera (two-winged flies).—This order is scarcely less numerous in species than the Hymenoptera, to which it is second only in importance from the entomophagous point of view. The Tachinidae are probably the most important family of parasites among all insects; there are several other families entirely or mainly parasitic, and others that are predacious, either as larvae, such as aphis-eating Syrphidae, or as adults, such as the Asilidae or robber-flies. The order also contains many true parasites in the medical sense, both internal ones such as the warble-flies and external such as mosquitoes.

Aphaniptera (fleas).—All fleas are ectoparasites of mammals or birds, but none of them is a parasite or predator in the entomological sense.

The Habits of Predacious Insects

As a rule predators are more general feeders than parasites and they tend to feed indiscriminately on any insects they are able to catch. There are, however, many exceptions; the lace-wing flies and lady-birds feed mainly on aphids, scale insects and mealy bugs, and some Syrphid larvae probably feed entirely on aphids.

The commonest modifications of structure for a predacious life are greatly enlarged raptorial forelegs, such as those of the praying mantids; and among biting insects large, frequently curved, mandibles; but neither of these features is necessarily present even among the most voracious of predators.

Predacious insects can be arranged, by their habits, in the following categories.

Actively searching for their prey

(*a*) In the air.—The Odonata (dragon-flies) are the best known example. Their prey must obviously consist of winged insects and species of Diptera, Lepidoptera and Hymenoptera form the bulk of it. A family of the Neuroptera, Ascalaphidae (the adults of which somewhat resemble ant-lions in appearance), also hawk their prey while in flight. So also do some species of Asilidae (robber-flies). They usually rest on a point of vantage in a sunny spot and wait for some insect to come into their area, when they immediately dart off and capture it. They often attack insects, such as dragon-flies, larger than themselves.

(*b*) On the ground or on vegetation.—The commonest examples are the Reduviidae and other predacious bugs; the Carabidae, Cicindelidae (adults only) and certain other predacious beetles; many species of ants, the predatory wasps, and several families of Diptera. Some species of Reduviids which prey very largely on the cotton stainers (*Dysdercus*) have a strong superficial resemblance to the latter insects. The Carabidae are for the most part nocturnal, hiding under stones by day and seeking their prey at night. The Bombardier beetles, however, are diurnal; they are of particular interest because, long before man had learnt to make even the most primitive flint weapons, they had evolved the use of poison gas and smoke screens. They are able to emit a caustic fluid which volatilizes with a distinctly audible report and a puff of smoke. They appear, however, to employ their artillery more as a means of defence than of attack. Several families of the wasps are of interest because the adults catch other insects, not for themselves but for their larvae. Their captures are paralysed, but not killed, by being stung and a supply of fresh food thereby ensured. Thus the Eumenidae provision their nests chiefly with small lepidopterous larvae, the Pompilidae use spiders exclusively, and the Sphecidae caterpillars and grasshoppers. On the other hand the Vespidae feed their larvae with bits of insects—usually caterpillars—which they have previously masticated. So also do the semi-social Bembecidae, but this family preys on Diptera, catching large species such as horse-flies and tsetses.

Some of the Empidae, a large family of small predacious flies which are more abundant in temperate than tropical regions, have the following curious habit in connexion with mating. Before seeking a female, the male first catches and kills some small insect and flies round

with it until meeting a female. The male then presents his capture to the female and if she accepts it, copulation then takes place, during which the female feeds on her wedding present.

(c) In water.—Actively predacious aquatic insects are found in several orders. The nymphs of dragon-flies are extremely voracious, they have a modified labium (lower lip) which is extensible and used, very efficiently, to seize their prey.

The predacious aquatic bugs have already been mentioned; the larvae of many water beetles have similar habits. The most important families are the Dytiscidae, Gyrinidae (whirligigs) and Hydrophilidae. These, like the predacious aquatic Hemiptera, do not confine themselves to insect food but attack crustacea and tadpoles and small fish.

Comparatively Inactive Insects

Although there is no hard and fast dividing line between this group and the last, there are many insect predators that are sluggish in habit and live permanently in close proximity to the insects on which they feed. It therefore follows that the latter must also be comparatively inactive insects and that this type of predator will tend to be more specific in its feeding-habits than those which actively search for their food. Most predators of this group are larvae: the eggs must therefore have been laid by the parent reasonably close to a supply of food. Many of the most valuable—from an economic point of view—of insect predators are of this type, perhaps because their prey commonly consists of insects belonging to those most injurious families—aphids and scale insects and mealy bugs.

Among the Neuroptera, the larvae of the green lace-wings (Chrysopidae) and brown lace-wings (Hemerobiidae) are the most important. The former have the habit of camouflaging themselves by sticking the sucked bodies of their victims on to the spines on their back. When the larva moults this camouflage is of course shed with the cast skin, but it is quickly renewed. A somewhat similar form of concealment is adopted by the larva of the Noctuid moth *Eublemma*, which lives in a case constructed mainly of the dead bodies of scale insects and mealy bugs. Many lady-bird beetle larvae secrete a waxy material which superficially renders them very similar in appearance to the mealy bugs which constitute their food. Adult lady-birds also feed on aphids, mealy bugs, etc., but they are not so voracious as their larvae. Among the Diptera the larvae of many species of Syrphidae (hover-flies) are probably the most important check on aphids. They are unattractive slug-like maggots, which pierce the aphid with their pointed, hooked mouth-parts, raise it in the air and rapidly suck it dry. They are believed to consume several hundred aphids during the course of their development.

Inactive insects, which wait for their prey to come within reach

(a) Relying on their immobility.—Conspicuous among these are the Mantidae, which (contrary to general opinion) seldom stalk their victims. Normally they are by no means inactive insects, but when actually on the look-out for food they remain motionless for hours at a time waiting for a suitable insect to come within reach of their powerful raptorial fore-legs.

Another example is the curious larvae of the Neuropterous family Nemopteridae, the adults of which are beautiful delicate insects with enormously long ribbon-like hind wings. The larvae live in the dust on the floors of caves, and in similar dry situations, waiting for some insect to come within reach of their large curved mandibles, the effective range of which is increased owing to the head being at the end of a long swivel-like neck. These insects, like those in the next group, relying as they do almost entirely on chance for their food, are able to go for long periods without a meal.

(b) Constructing traps in which to snare their prey.—Considering the great diversity of habits of insects, it is perhaps somewhat surprising that the method of trapping their prey has only evolved in comparatively few species in four orders. But it is still more surprising that in two of these orders, which are no more closely related than monkeys and mice, the method of trap-making should be almost identical.

The best known of them are the ant-lions (order Neuroptera), the pits of which are common in all dry sandy places in warm climates. The ant-lion larva, an oval insect with a flat shovel-shaped head and powerful mandibles, remains motionless at the bottom of its pit, only its mandibles appearing above the sand. As soon as any insect happens to fall into the pit it is immediately seized, pulled below the sand and devoured. The sucked body of its victim, as well as any inedible object that may fall into the pit, is subsequently ejected by a flick of the ant-lion's head.

Their method of constructing a pit is interesting. The larva first digs a circular ring of the diameter of the pit that is to be dug, by moving backwards and flicking out the sand with its head. It then proceeds, always backwards, in narrowing spirals until all the sand left in the centre of the original ring has been excavated.

The other insects that make very similar pits are the larvae known as "worm-lions," which belong to the Dipterous family Leptidae. They are elongate maggots, the body thicker towards the posterior end; the head is very small and they are without legs. They construct their pits in a much simpler way than the ant-lions although the final result appears almost exactly the same and just as efficient. The larva first burrows just under the surface of the sand, where it lies on its back, bends its anterior end downwards into the sand and then suddenly flicks it up, thus excavating a small portion of sand. It moves round occasionally so that the sand is thrown out in different directions. When a small pit has been made it burrows a little deeper and continues until a sufficiently large pit is completed. It then lies, still always on its back, with the head and thorax just covered by the sand at the bottom of the pit, and waits for the chance of a meal. When an insect falls into the pit, the worm-lion embraces it by its thoracic segments, drags it under the sand, and inserts its mandibles in a soft spot. Judging by the short duration of the struggles of their prey, both ant-lions and worm-lions probably inject a venom.

The pit made by the larvae of the Cicindelidae, or Tiger beetles, should perhaps be called an ambush rather than a trap. The adults, which are elongate beetles with metallic, often spotted, elytra, are very active predators. The larvae make vertical, narrow cylindrical burrows, said to be sometimes as much as 6 ft. in depth but more usually 1-2 ft. When on the look-out for prey, they lie upright at the entrance to the burrow, their large head, which is somewhat deflexed, being flush with the ground, and strike rapidly at any insect that comes within their reach. Their legs have sharp claws and on the dorsum of the fifth abdominal segment there is a hump with a pair of forwardly projecting hooks, which serve to anchor them in their burrows when dealing with the struggles of an insect they have captured. Several species are common in East Africa and their burrows can often be found in the compact earth of roads and paths.

The two other groups of trap-making predators construct nets. The Mycetophilidae, or fungus gnats, are a family of Diptera that for the most part feed on fungi, as their name implies. There are, however, a few species that are predacious and the larvae of these make slimy webs which entangle small insects and kill them. The poisonous principle of the slime is said to be oxalic acid. One species of Mycetophilid has evolved a refinement on this method. This is the "New Zealand glow-worm" (ordinary glow-worms, it should be noted, are Lampyrid beetles, not Diptera) which lives in damp caves, the larvae feeding on the chironomid midges which breed in the water in the caves. The larva makes a tube-like web, in which it lives, on the roof of the cave and also a number of hanging threads, several inches in length, covered with a poisonous sticky substance. The light given out by the larva attracts the midges, which get caught in one of the hanging threads, which is then pulled up by the larva and the victim is eaten.

The other net-makers are the aquatic larvae of certain species of caddis flies (Trichoptera). Most of these insects construct cases of vegetable matter, gravel, etc., and these forms are probably all vegetable feeders. Some, however, do not make portable cases but a fixed underwater retreat, near the mouth of which they construct a miniature fish-net which snares minute insects and other organisms on which they feed.

It will be observed that all these snare-making predators are larvae. So far as I am aware no adult insect has developed this habit.

Social Predators

Some species of ants might be called social predators, in that the whole colony lives by plundering other less aggressive species of ants. Some of these waylay the workers of the other colony and rob them of the food that they are bringing back to their nest. Others invade the nests of the more pacific ants and remove their larvae and pupae, which they use for food. This does not invalidate the somewhat disparaging comparison between the habits of insects and humans, made in the opening paragraph of this article, for there are no ants that pillage, murder or enslave their own species.

The Habits of Parasitic Insects

Parasites that do not cause the death of their host

As stated above, the definition of a "real" parasite is an organism that obtains its food at the expense of its host, but does not kill it. Brief mention has already been made of those groups of insects that are parasitic in

this sense on the larger animals, chiefly mammals and birds, and it is not proposed to deal with these in any greater detail. "Real" parasites of insects are for practical purposes confined to the Strepsiptera and one aberrant family of Diptera.

The Strepsiptera, commonly known as "Stylops," are parasitic mainly on Hymenoptera and Hemiptera. Both sexes are endoparasites to start with. The female remains larviform, though when adult its head and thorax are extruded from the body of the host, the abdomen remaining inside. The male pupates within the host, extruding its head and thorax in a similar way to the female, but the adult male is a free-living winged insect which escapes from its host to live an active life of only a few hours. The male fertilizes the female through an opening in its extruded head-plus-thorax (which is the only part accessible), mounting on the back of the host insect to do so. The fertilized female is viviparous, not laying eggs but giving birth to very large numbers (several thousand in some cases) of minute active larvae, which escape from their parent, and from their parent's host, and wander about till they find, or are picked up by, another suitable host insect, which they penetrate. The method by which the young larva finds a host and penetrates it has, I believe, only been observed for one species, an East African parasite of Antestia. Certainly nothing is known as to how this is effected by those species that parasitize Hymenoptera. The Stylops does not kill its host, though if an undue number develop within a single host its life may be shortened, but female hosts invariably, and male hosts usually, become completely sterile.

Braula is a small degenerate wingless Dipteron, cosmopolitan in distribution, which lives on honey-bees. The larvae are said to enter the cells of the honey comb and feed on the honey provided for the larvae of the bees. The adults attach themselves to the queen and worker bees, seldom to the drones, and somehow or other induce the bee to regurgitate honey on which they feed. It is believed that they do little if any harm to the bees.

To show how arbitrary is the distinction betwen a "true" parasite, which does not kill its host, and a "parasitoid" which does, the case of *Euphorus*, a parasite of *Helopeltis* (a capsid bug which attacks Cinchona, cotton and other plants in East Africa and elsewhere) is of interest. If the *Euphorus* lays an egg in one of the earlier nymphal stages of a *Helopeltis*, the latter never becomes adult and dies very soon after its parasite has completed its development. But if, as frequently happens, a fifth (that is the last) stage nymph is attacked, it becomes adult and the subsequent emergence of the parasite has no ill-effect on it. *Helopeltis* bugs parasitized as fifth stage nymphs have been found to live just as long and to be just as fertile as unparasitized ones.

It is also stated that some species of Epipyropidae, a curious family of moths of which the larvae are external parasites on Fulgorids, are non-fatal parasites. Since, however, the only species of which I have any first-hand knowledge invariably causes the death of its host, this family will be mentioned in its place as a lethal parasite.

As has been said, the great majority of insect parasites cause the death of their host. These may be grouped according to the way in which the parasite finds its host.

The eggs are laid in a situation remote from the host

In all these cases large numbers of eggs are produced, sometimes several thousand, because the chances of any one individual parasite successfully finding a host are very small.

(*a*) The eggs hatch into active free-living larvae, which are different in appearance from the subsequent parasitic lava, and which wander about until they come in contact with a suitable host. This habit has developed in the Hymenopterous family Perilampidae, which are mainly hyper-parasites feeding on either hymenopterous or dipterous primary parasites of certain caterpillars. Survival is therefore dependent not only on the Perilampid larva finding the right caterpillar but also on that caterpillar having already been parasitized. Another family of Hymenoptera, the Eucharidae, is of interest because they practise phoresy. This term means the use of one animal by another as a vehicle of transportation. The eggs of the Eucharidae are laid on trees frequented by ants attending aphids. The primary larvae attach themselves to worker ants, by which they are carried to the ants' nest, where they become ectoparasites on ant larvae. Other examples of phoresy will be mentioned later.

Certain Tachinid flies also have primary larvae. Some species burrow in the ground in search of the grubs of scarabaeid beetles; others parasitize earwigs.

There are very few parasites among the Lepidoptera, but one family of moths, Epipyropidae, is of considerable interest. The only

species of which I have first-hand knowledge lays its eggs on the trunks of trees that are, at certain times of the year, frequented by large leaf-hoppers of the family Fulgoridae. The eggs hatch into very active primary larvae which become external parasites on the adult Fulgorids. (This is one of the comparatively few cases, apart from the Aphids and Coccids, where an adult insect and not one of the earlier stages is attacked.) When the larva is full grown it leaves its host and pupates on the tree trunk; the host usually dies soon afterwards.

Probably the only other family of Lepidoptera that contains genuine parasites is the Cyclotornidae, the habits of which are of peculiar interest. Large numbers of eggs are laid on plants in the neighbourhood of colonies of Jassid leaf-hoppers which are atended by the ant *Iridomyrmex*. The young larvae on hatching move about until they encounter a Jassid, on which they become ectoparasitic. Several larvae may attach themselves to a single host. These larvae, while still in the first stage, leave their Jassid hosts and make a silken web, in which they undergo the first moult. The second-instar larva then leaves the web and remains stationary with both ends of its body raised into the air. If it is found by the *Iridomyrmex* ant, it is seized and carried to the ants' nest, where it feeds as an ecto-parasite on the ant larva and also secretes a substance which is eaten by the adult ants. When full grown the larvae leave the ants' nest and pupate on the trunk of a tree. The two most remarkable points in this life history are the compulsory change of host and the fact that they are dependent on the ants themselves for access to the ants' nest.

A few of the parasitic beetles also have primary migratory larvae. The Rhippiphoridae parasitize wasps, their eggs are laid on rotting wood and it is thought that they employ the adult wasps (when these are collecting scraps of wood for their nest) as a means of transport to the wasps' nest. There they are first of all endoparasites of the wasp grubs but towards the end of their development they become ectoparasites.

Several species of Meloidae (blister beetles) are known as parasites of locust—and grasshopper—eggs in East Africa and elsewhere. These also have migratory primary larvae which wander through the soil until they find an egg capsule of a locust. Since a single larva feeds on more than one egg in a capsule, these insects could, according to the definition given above, be considered as predators. It will be observed that the habits of their larvae are very similar to those of the Mantispidae, but adult Meloids are all plant-feeders. Other species of Meloidae, which are parasitic on social bees, afford another example of phoresy. The eggs are laid outside the nest and the young larvae attach themselves to male bees from which they subsequently transfer themselves to the female bees in the nest. When an egg is laid in a cell the larva detaches itself and gets sealed up in the cell, where it first feeds on the bee's egg and subsequently on the honey.

Active primary larvae, differing in appearance from the subsequent parasitic larval stages, have therefore been evolved in six separate orders—Hymenoptera, Coleoptera, Diptera, Lepidoptera, Strepsiptera and Neuroptera.

(*b*) The eggs hatch into inactive larvae, which remain on their egg-shell until picked up by a host. This is known to occur with some Tachinid flies that are parasitic on cutworms and other caterpillars, but does not seem to be of common occurrence.

(*c*) The eggs do not hatch until swallowed by the host. There is one group of Tachinid flies which lays very large numbers of very small eggs, scattering them over the foliage on which the hosts—which are all Lepidopterous caterpillars—are accustomed to feed. These eggs do not hatch until they happen to be eaten by the caterpillars, when the resulting larva becomes on endoparasite. The eggs of Trigonalidae (Hymenoptera) are also laid on leaves and are swallowed by caterpillars, inside which they become hyperparasites of Tachinid or Ichneumonid primary parasites. If they are swallowed by an unparasitized caterpillar they die.

The eggs are laid externally on the host

Since the chances of survival are obviously so much better in this (and the next) group of parasites the number of eggs produced is usually very much smaller than in the preceding group. This method is adopted by many species of the three great families of parasitic Hymenoptera, Chalcidae, Braconidae and Ichneumonidae, by most of the Dipterous family Tachinidae, and by a few other Diptera. The outstanding difference is that the larvae of the Hymenoptera are ectoparasitic whereas those of the Tachinidae are invariably endoparasites. In a few cases in both orders, where the host lives in a restricted and concealed habitat, such as a leaf-mine, the eggs may not be actually laid on the host, but very close

to it. Some of the Ichneumonidae which parasitize wood-boring larvae have immensely long ovipositors to enable them to reach the vicinity of the host. One species is said to have an ovipositor six inches in length, although the body of the adult is only some ¾-in long. Some of the Tachinidae in this group are viviparous and deposit living larvae instead of eggs on the host, and some are ovi-viviparous, that is to say they lay eggs which hatch almost immediately. In both these cases the young larvae penetrate the host at once.

The eggs are laid inside the body of the host, the resulting larvae always being endoparasitic

This is the most frequent habit among the endoparasitic Hymenoptera, it also occurs in a few Tachinidae and one or two other families of Diptera. Whereas in the preceding groups it is nearly always the larval stage of the host that is attacked (though there are a few exceptions, some of which have been mentioned), this group contains, as well as a large number of larval parasites, very many egg parasites (all Hymenoptera) and a few species that insert their egs into the pupa or the adult of the host.

(*a*) Egg parasites completing their whole development within the egg of the host. The principal families in which this occurs are the Mymaridae, Scelionidae and Trichogrammatidae. The Mymaridae are among the smallest of insects, which is not surprising when it is considered that their whole development takes place in a single egg, often of an insect that is itself by no means large, such as a Psocid. The eggs of several order of insects are attacked and some species have been used in biological control, e.g. one species has been successfully introduced from Australia into South Africa for the control of the Eucalyptus snout-beetle. Certain species parasitize the eggs of aquatic insects such as dragon-flies and water-beetles: in order to find the eggs the adults are capable of swimming under water.

The Scelionidae also parasitize the eggs of several different orders of insects and in several instances phoresy occurs. Thus one species attacks the eggs of Mantidae. The female parasite attaches itself to the female mantid and is thus on the spot ready to lay its eggs in those of the Mantid as soon as the egg mass of the latter has been deposited and before its frothy covering has toughened. The Trichogrammatidae are chiefly remarkable for their polyphagous habits. Thus *T. minutum*, which has been extensively used in biological control, is known to attack the eggs of more than 150 different insects belonging to seven separate orders.

(*b*) The eggs are laid in the egg of the host, but development is completed in the larva. This occurs only in the Hymenoptera, but in several widely distinct families of that order, being most common in the Braconidae. The hosts are usually Diptera or Lepidoptera. A few species are known of which the egg is laid in the egg of a Dipteron and the adult parasite emerges from the pupa of its host. Although parasites of this type are often called egg-parasites they are quite different in habit from the real egg-parasites which complete their whole development in the egg of their host, for there is probably little or no development of the parasite before the egg of the host has hatched.

(*c*) The eggs are laid in the larva of the host. This is the usual procedure with the great majority of the Ichneumonidae, Braconidae and Chalcidoidea among the Hymenoptera, and with a few Tachinidae and the family Pipunculidae among the Diptera. The full-grown parasite larvae may emerge from the larvae of the hosts, or sometimes the latter develop as far as the pupal stage before they succumb. Some of the Ichneumonidae pupate inside the pupal case of the host, but most species of the other families leave the host for pupation. Braconids often spin their cocoons on the exterior of their late host; several hundred of the tough white cocoons of *Apanteles* may sometimes be seen adhering to the shrivelled skin of a caterpillar. Many Pteromalids (super-family Chalcidoidea), as well as some other Hymenoptera, completely paralyse the host larva by repeatedly stinging it before inserting their eggs. Some even kill it; in such cases the resulting larvae are not really parasites but saprophagous. The Pipunculidae, curious little flies with long wings and very large eyes, parasitize Homoptera, particularly Jassids and Fulgorids. They are very agile on the wing and they pounce on a leaf-hopper nymph, carry it into the air and insert their egg into it while flying, subsequently dropping the nymph. Some of the Tachinidae in this group, as in group 3, are viviparous and insert a larva instead of an egg into their victim.

(*d*) Some Hymenoptera, particularly of the families Pteromalidae and Encyrtidae, are exclusively parasites of pupae. Lepidopterous pupae are not very often affected (although

these families contain large numbers of species that attack lepidopterous larvae). *Pteromalus puparum*, however, is a common and useful parasite of the Cabbage White butterfly in Europe, and has been successfully introduced into New Zealand. Diptera of the house-fly type are not uncommonly attacked and so are occasional Coleopterous pupae. Some Mutillidae (a family commonly known as "velvet ants", though they are not ants but wasps) attack the pupae of tsetse flies. The female bites a hole in the pupa, a process which takes half an hour or so, and then lays an egg through the hole.

(*e*) The hosts are adult when parasitized. Apart from the numerous Hymenoptera of many families that lay their eggs in adult aphids, scale insects and mealy bugs, parasitic attack on adult insects of other orders is not common, though it has developed in at least two families of Hymenoptera and three of Diptera.

The genus *Perilitus* (Braconidae) inserts its eggs in adult lady-bird beetles. The attack is not always fatal, though the reproductive capacity of the beetle is impaired; indeed a single host has been known, experimentally, to produce two consecutive parasites. Possibly this parasite should have been included among the "non-fatal" parasites mentioned in Group 1. Another species of Braconid is said to parasitize adult ants, laying in wait for them at the entrance to the ants' nest and inserting an egg into the abdomen of the ant. The Dryinidae are a family of Hymenoptera with the front tarsi curiously modified into a pair of forceps, adapted for gripping the host during oviposition. They are all parasitic on Homoptera, and though mainly attacking the nymphs, some species only attack the adult. One species, for some obscure reason, confines its attack to adult females.

The habits of those few Diptera that lay their eggs in adult insects are of considerable interest. The Conopidae are (so far as is known) all endoparasites of adult Hymenoptera. Many of them bear a striking superficial resemblance to their victims, on which they pounce while in flight for the purpose of oviposition. The genus *Stylogaster*, which is not uncommon in parts of East Africa, has some connexion with *Siafu* ants (Dorylus) and the females may be seen hovering over the columns of these ants, but the exact relationship has not been determined. The Phoridae are a family of small hump-backed flies with a very distinct venation. Many are scavengers but there are also a number of parasitic forms whose hosts include spiders and millepedes as well as several different orders of insects. Some species attack adult ants—usually workers—and there is one species that does considerable damage to hive bees. The egg is inserted into the abdomen of the bee and at first the young larva causes little harm, but later it migrates to the thorax and the bee finally succumbs.

Only a few species of Tachinidae parasitize adult insects but the hosts of these few belong to several different orders. Thus *Epineura* is a valuable parasite of adult Antestia (*Hemiptera*, Pentatomidae) in parts of East Africa; there is one that attacks the destructive Japanese beetle, and another that parasitizes the European earwig.

Social parasites

Finally, brief mention may be made of a type of parasitism that is much more closely in accord with the dictionary definition of the word. Social parasites, or cuckoo parasites, are insects that feed not on the host itself but on its food stores. They are, therefore, for the most part parasites of colonies of social insects, though the larvae of a few species of Chrysididae (ruby-wasps) feed on the prey sealed up in the cell of their hosts, a species of mud-wasp, after having first destroyed the larva of the mud-wasp. Social parasites are usually fairly near relatives of their hosts and often have a superficial resemblance to them. A well-known example is the genus *Psithyrus*, which parasitizes another genus, *Bombus*, of bumble-bees. A queen *Psithyrus* enters a *Bombus* nest in the spring and after a number of *Bombus* workers have been produced, stings their queen to death. The offspring of the *Psithyrus* are males and females only, which are reared by the *Bombus* workers, for *Psithyrus* does not produce workers, and the females are not provided with the usual pollen-collecting apparatus on the hind legs. Similar examples are known among the social wasps.

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The foregoing account of the habits of entomophagous insects makes no pretence of being complete, but is merely a brief account of most of the more important and a few of the more interesting types of predators and parasites.

SIEGE FARMING IN MALTA

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Malta Pre-war

Malta and Gozo contain some 45,000 acres of arable land on the 114 square miles of their rocky islands, of which some 2,000 to 3,000 are under irrigation. While this area, obviously, cannot support the population of over a quarter of a million, besides the Services, it keeps the 13,000 peasant farmers who, with their families, total some 70,000 souls, fully fed. Ample supplies of fresh vegetables, potatoes, onions and milk are sold to the civil and Service inhabitants of the towns and Mediterranean clover, vetches and carobs to the urban goat-keepers and to the carters for their horses. Despite this, however, the bulk of the food requirements of Malta have to be imported as well as many thousands of tons of feeding stuffs and 2,000 tons of seed potatoes per annum. The only agricultural exports of importance in peacetime were 10,000 to 15,000 tons of potatoes to Britain and the Continent of Europe, 2,500 tons of onions and 250 tons of cumin seed, their total value being about £130,000 annually.

Rainfall is confined to the autumn, winter and spring months, rain before October or after April resulting in particularly good seasons. The limestone rock, lying close to the surface, retains and supplies moisture to the roots of crops during the summer months so that as many as two crops may be grown in a year and, under irrigation, two main crops and two catch crops.

Sir Frank Stockdale, at that time Agricultural Adviser to the Colonial Office, visited and advised the Islands in the early 1930's to replace the 10,000 to 15,000 fat cattle imported annually from the Continent for immediate consumption by store stock for local fattening, giving a livelihood to the farmers, providing them with large quantities of muck to maintain the fertility of the land and enabling them to retain straw crops in their rotation. The visit also resulted in the appointment of an adviser in animal husbandry and controller of export produce, the latter to improve the quality of produce exports by grading. By the time war broke out a flourishing pig and pork industry had been built up based on the exclusive use of the Large White pig, and plans were being drawn up for converting the surplus into bacon and ham products. Improvement of poultry, to offset the annual imports of 700,000 dozen eggs, and of sheep had received considerable attention, a breeding station being established on the farm of the Agricultural Department at Ghammieri. Stud rabbit centres were maintained at several places and rabbit keeping by householders was particularly encouraged in war time by an issue of bran to all does served at these centres. Improvement in the quality of local rabbits was being brought about by the use of Flemish Giant bucks.

Dairy cattle were not numerous, being kept mainly by farmers for local needs, and they were often used, together with oxen, for ploughing, as were mules and, to a certain extent, donkeys. Fields were too small to permit the use of any but a few tractors. Farmers relied for their milk and cheese supplies mainly on sheep. The bulk of the Islands milk supplies came from the goats kept by the herders in the towns who sold their milk either to the Milk Marketing Department or to the public by driving the flocks through the streets and milking them into jugs on their customers' doorsteps. The Milk Marketing Department had been established for the collection and pasteurization of goats' milk to combat the prevalent disease of Malta or undulant fever by buying milk from registered goat-keepers and redistributing it to the public after pasteurization at central stations. The Milk Marketing Department did not handle cows' milk, which was unfortunate, as town dairies would have been of great benefit to consumers. A world-wide reputation had imputed to the Maltese goat a very high milk yield but, soon after the establishment of the Milk Marketing Department and the collation of records, it became obvious that in fact the milk yields of the goats were exceptionally low. While pasteurization was a prophylactic remedy for the incidence of Malta fever, at the same time long-range research into the activities of the Brucella organism, a close relative to the contagious-abortion germ in cattle, was being pursued by the veterinary officers of the Agricultural Department and, based on American work, it was hoped that it would be possible ultimately to clean the Islands completely of brucellosis.

* Mr. Swynnerton was agricultural officer in the team led by Mr. A. B. Cohen, which was sent to Malta in 1942, by the Secretary of State for the Colonies, to make the islands as self-supporting as possible in food.—*Ed.*

As visitors to Malta well know, it presents an appearance of barren limestone rock and of being heavily built up. But if one climbs upon the walls which line the roads one sees fertile valley bottoms (*wieds*) and terraced and walled hillsides, rock having been dug and hewn to construct the walls and the pockets of earth built up into fertile fields by careful husbandry. The fable that much of the soil has been shipped into the Islands is only true in so far that in the past an occasional shipload of ballast had been cast ashore. However, the value of soil is appreciated to such an extent that the soil from all building sites must be removed under the Fertile Soil Preservation Ordinance and deposited on farms or rocky places for agricultural use. For instance in 1938 [1] 79,000 cubic yards of soil were saved in this way. In parts of Malta and Gozo clay underlies the limestone rock and prevents the rainwater from seeping away to sea level. At sea level another reservoir, which may be fresh or partially brackish, is said by some experts to be held up by the pressure of sea water. At other points, particularly in Gozo, which is more fertile and productive than Malta, the clay crops out on the surface. The two subsoil water levels are tapped by wells and boreholes to supply the domestic needs of the islanders and to irrigate some 2,000 to 3,000 acres. The elaborate system of underground galleries, wells and reservoirs was well adapted to withstand the heavy bombing which the Islands underwent without seriously endangering the domestic water supplies. The farmers raised their water by Persian wheels rotated by mules, by windmills and oil engines, and each farm had a reservoir for conserving surplus and night flow. In all, well over 1,000 mechanical appliances were used for lifting irrigation waters. This underground water supply had just about been tapped to capacity without exploring much greater depths, new wells generally causing a falling off in the flow of neighbouring wells.

Besides the peace-time production of wheat, barley, field beans, vetches, Mediterranean clover and carobs (locust beans) to supply farmers' domestic requirements and for sale to goat-keepers and carters and the production of vegetables, potatoes and onions for sale in the towns and for export, large acreages of vines, the plantings of which had greatly expanded in recent years as a cash crop, and of citrus, protected by high walled-in gardens, were grown. Figs and temperate fruit trees were grown along the walls of fields and prickly pears occupied any waste space, the fruits being appreciated by the Maltese and the succulent stems fed to goats. From the rapidly expanding vineyards large quantities of table grapes were sold locally but more than half were converted into wine of very ordinary quality and generally not fit for export. Distribution of high-quality varieties on Phylloxera-resistant stocks was made regularly from Agricultural Department nurseries, and sulphur dusting was maintained regularly against mildew under the supervision of experts, sufficient sulphur being held in stock to enable dusting to be continued throughout the year. It had been proved at the Government farm that the production of good-quality wine was possible.

Beekeeping forms a not unimportant local industry for the Maltese farmer, the honey acquiring a special flavour from the thyme growing on the rocky wastelands. It had been expanded before the war by means of a Government subsidy.

Siege Farming

These, then, were the conditions pertaining on the outbreak of war and faith in the Royal Navy was such that it was not until early 1942, when the German blockade and bombing reached their peak, that it was realized that starvation might become a greater menace to Malta than the bombing, very adequate protection from which had been carved in the limestone rock by the Shelter Construction Department to supplement the catacombs of an earlier age. After a series of convoys had been severely crippled, sunk in Valletta harbour or turned away by the threat of enemy action in the first half of 1942, Lord Gort, V.C., the newly appointed Governor, took the islanders into his confidence in a broadcast over the Rediffusion system, and warned them that the food ration must be drastically curtailed in order that the Islands might hold out until a "target-date" by which it was hoped that a convoy would arrive to postpone, at the least, the target date, if not ameliorate the food shortage. The ration was cut to the bare minimum for a sedentary diet, 1,500 calories a day, though this could be supplemented from the controlled vegetable-distribution scheme and by registering for a meal a day at the Victory Kitchens. The Maltese, generally heavy starch eaters, were restricted to ten ounces of bread a day and no macaroni. For those that had the means eggs could be purchased at the rate of five for a half-crown note and occasional chickens and rabbits for twenty-five shillings apiece. The Army, too, normally superabundantly rationed,

pulled in its belt to the civilian standard. Pre-war, rabbits and poultry cost Sh. 1/6 each and eggs eight pence a dozen. All restaurants were closed.

By this time potatoes had become almost unobtainable. Although Malta could produce an ample surplus under normal conditions by raising three crops a year, a big winter crop, a big spring crop and a small summer crop under irrigation, seed supplies essential to the maintenance of healthy stock were no longer obtainable. Potatoes have a dormant period, although recent research has shown that this can be overcome by suitable heat and chemical treatment. The winter crop harvested in December in Malta would not sprout in time for January planting, while it was hard to store the spring-harvested crop over the hot summer months without severe damage by Potato Moth. The summer-planted crop was small as irrigation water was also required for vegetable production. Hence the necessity in peace-time to import some 2,000 tons of seed potatoes in winter, the favoured source of supply being Northern Ireland. But in 1942 it was not possible to run in the requisite seed supplies and it was only possible to obtain a few hundred tons of seed grown in Cyprus in time for late planting in what was a dry spring, so that a very meagre crop was forthcoming.

It should be noted that the pre-war total arable acreage had been somewhat reduced by the expansion of aerodromes and their dispersal areas, by military camps and gun and search-light sites, and by bomb damage, although farmers received assistance wherever possible to fill in craters. Attempts to burn standing straw crops proved as great a disappointment to the enemy as his efforts to burn the towns with their flat limestone-tiled roofs and a minimum of timber. Shipping space had such urgent priorities that the thousands of tons of feeding stuffs required to maintain the Islands' live stock had to be replaced by a fraction of that quantity of dried milk.

At this point the Agricultural Department was called upon to play a vigorous part in supplementing the food reserves and in increasing the production of staple crops. A seed specialist was secured to ensure that the correct vegetable seeds, which had to be flown in in precious air space, were imported and to investigate the possibilities of local production of seed, although this showed more promise as a post-war development. In June, 1942, the only contribution to increased production could be to plan for the autumn plantings but in the meantime the edict had gone forth that the live stock population had to be drastically reduced and requisitioning and slaughter of the pigs and goats was put in hand at once. In about three months the pig population was reduced to a bare minimum, pork being rationed as well as issued to Victory Kitchens. The slaughter of goats, taken because they depended on the import of feeding stuffs and on fodder from farmers, was most unpopular both with the goat-keepers and with the consumers. In fact so disliked was goats' meat that, ultimately, combined with equines slaughtered from lack of keep or on account of injury from enemy action, they were converted into "veal loaf". The story was circulated that one good lady, finding her dog refused to eat the meat offered to it, took it to the Police. On visiting the butcher's shop concerned, a row of dogs' heads was found on a shelf. However, the goat-keepers received a firm promise that goats would be imported after the war to make up the depleted herds, which would provide an excellent opportunity for improving milk yields. Although the policy was not to slaughter breeding cattle and sheep, considerable numbers were brought in to the abattoir, kept running despite heavy damage by bombing. Vaccination of the few remaining pigs against erysipelas was continued by the veterinary officers.

The retention of horses was an urgent priority on account of the shortage of petrol, private cars having all been laid up and the bus services curtailed to mornings and evenings only to transport workers to and from their jobs. Not only were carters in urgent demand to transport produce to market but they were also required on military works. Occasional distributions of fodder for horses were made and whenever damaged foodstuffs were salvaged from wrecks, they were made available as pig-feed. Generally, however, stock owners had to fend for themselves in the search for fodder for which the prices paid were often fantastic. While the policy, wherever possible, was to import grain for milling in order to provide offals for live stock, this was seldom possible, particularly as it was found that flour bags salvaged from wrecks sealed themselves off on contact with sea water and the flour in the centre of the bags was still usable.

It was estimated from half-yearly returns that the grain harvest would bring in about 5,000 tons of cereals and of this about half was requisitioned to supplement the bread ration of the population. Village mills were

closed down to prevent surreptitious grinding, but farmers were allowed to retain a quantity of grain for their own consumption as well as their seed for the coming year's increased plantings. Another crop which was requisitioned during the winter was the oranges which were issued regularly to children. Potatoes were requisitioned and retained as they became available. The coffee ration consisted of barley, roast and ground.

At this time the records of land tenure were inadequate to permit of individual cropping orders to farmers, the average of whose holdings was in any case only three to four acres, as was being done in Britain, so that orders for the 1942/43 plantings had to be in general terms. All farmers were required to plant 50 per cent of their land to wheat or barley, raising the average annual acreage under these crops. The area under Mediterranean clover was restricted to a given acreage per farmer's registered draught animals, while vines, occupying valuable farming land, were ordered to be interplanted with field beans. This latter order, unfortunately, was not effectively carried out, as seed arrived too late for planting. It was hoped, despite the pre-occupation of shipping with the North African campaign, to be able to import sufficient seed potatoes from Britain, but in the end only small quantities were run in by the Royal Navy's gallant mine-laying cruisers, though seed was forthcoming again at a later date from Cyprus.

The inheritance laws of Malta result in such fragmentation of land that often an acre field may be divided amongst eight or ten people and a farmer's holding may consist of many scattered small plots. Despite this it was considered advisable to undertake an agricultural survey of Malta and Gozo. Two experts from home came out to organize this work and, finding that it would take an impossible time to complete, enrolled the spare-time assistance of scores of literate Maltese, particularly schoolteachers. While a map of 24 in. to the mile existed for Malta, the aid of the R.A.F. and U.S.A.A.F. had to be enlisted to produce a corresponding map of Gozo by aerial photography. The principal information recorded by this survey was the names of owners and tenants, demarcation of sub-divisions of fields, acreages, cropping, live stock, draught animals and types of wells. By the time the survey was completed, however, Benghazi had been relieved for the third and last time, Sicily had been invaded, regular supplies were being delivered to Malta and the control of cropping had been relaxed to almost pre-siege conditions. Steps were continued to improve water supplies for irrigation and to convert controlled marketing of vegetables into co-operative marketing to prevent farmers returning to the indebtedness to produce-buyers, a feature of the pre-war era, which had been paid off by the high war-time prices.

It has already been noted that the flourishing live stock industry in Malta had been largely responsible for the high state of fertility of the calcareous soils. But since 1940, when the Italians entered the war, the source of store cattle for producing dung had been cut off and the subsequent slaughter policy had further reduced the manufacture of manure. An organization existed for collecting all the refuse from towns and villages and taking it to a Refuse Disposal Centre where, after removal of tins and bottles, it was converted into compost. Difficulty, however, was experienced in disposing of this compost at a few shillings a ton and, in order to encourage its use, a newly arrived consignment of sulphate of ammonia was sold from this centre on the basis of one cwt. to any farmer who took a ton of compost. The compost sold like hot cakes thereafter.

A stray bomb damaged the sewage system running down from Rabat, the ancient capital of Malta, and adjacent farmers were soon producing heavy crops by sewage irrigation. Subsequently the sewage system was tapped at several other points for the same purpose, but the main sewage irrigation scheme was carried out on the grounds of the Marsa Sports Club which had been taken over by the Agricultural Department for food production. In the autumn all sewage irrigation was closed down as the annual increase at this time of year of dysentery and typhoid was greater than usual in 1942, although this might equally well have been attributed to the debris of bomb damage. Arrangements were made also, on the advice of an expert sent out by the Colonial Office, to import the most concentrated types of mixed fertilizers, which came forward gradually as the siege was lifted.

All this time very considerable propaganda and advice was being undertaken by the Agricultural Department's liaison officer together with the aid of prominent farmers in each district, all of which was very necessary to the successful pursuit of a policy which ran right across the traditional customs of the illiterate and very conservative peasant farmers. Propaganda was also carried out extensively by means of posters and talks to secure the planting of vegetables in private gardens and to

organize allotments on waste ground in the villages. A seed bureau was organized for the issue of seed and advice to smallholders. Maltese agricultural officers were appointed to the principal farming districts also to keep the farmers in touch with Government policy and to see it was carried out.

While production of vegetables for market is a speciality of the Maltese farmer, two main and two catch crops being raised a year from the same land, with the shortage of potatoes and the severe rationing of other foods it was necessary for the Agricultural Department to take over the local produce markets (*pitkali*) to ensure even allocation of the available vegetable supplies to all the towns and villages. Government purchased the vegetables from the farmers at these centres and resold them to the greengrocers on a quota basis. Although vegetables were in fair supply at most seasons of the year, contracts were placed with farmers for the production of vegetables at seasons when shortages were anticipated. By wide spacing a good tomato crop was raised on the subsoil moisture during the hot summer months and in peace time factories canned the surplus. Vegetables grown under irrigation were plentiful during the summer months. Magnificent cauliflowers came on to the market in autumn and spring. Pumpkins were carried over to alleviate any late winter shortage and the Jerusalem artichoke crop was a welcome substitute for potatoes. It was hoped to build a co-operative marketing system after the war on this controlled distribution.

With Government purchasing the bulk of the farmers' produce, it was still necessary to pay very high prices for such purchases in order to ensure that they did not disappear on to the black market and to resell them at prices within the means of the working man. This involved heavy subsidies which were generously met by the British taxpayer.

By the end of 1943 and beginning of 1942 [2], however, conditions had become more normal. With the movement of the bulk of the military forces into Sicily and Italy and with good early autumn rains, a glut of vegetables brought prices back to pre-war levels. This enabled the removal of vegetable rationing. A large surplus of tomatoes and pumpkins was once again converted into tomato paste at the canning factories. Ample supplies of seed potatoes were forthcoming from Scotland both for autumn and spring planting. Although there was considerable relaxation of crop control, it had been possible to issue individual cropping orders on farmers for cereal planting in the autumn of 1943 based on the recently completed agricultural survey. The numerous public gardens, for which Malta is noted, were being restored to normal from extensive bomb-damage and their use for food production. The Government vine nurseries, which had been used for vegetable and food production in the siege, reverted to their peace-time usage of supplying the farmers with the highest quality planting material. The rehabilitation of emergency runways, used for the invasion of Sicily, had devolved on the Agricultural Department and, despite oil dressings used to seal the runways, promising crops were grown.

Post-war Prospects

The Maltese farmer and stock keeper will have a difficult time for some years in the replacement of his soil fertility and his depleted stock. It may take several years to restore the flow of supplies of store cattle from the Continent and, while it is the intention to replace the slaughtered goats, it will take a considerable time if only the highest grades are to be imported with the object of raising milk yields. The possibilities of improving the rabbit industry by replacing the prevalent types with the dual-purpose modern pelt types was being investigated.

There are possibilities of developing a small seed industry. Successful small-scale seed experiments in 1943 [2] enabled contracts to be made by the Horticultural Officer with the United Kingdom trade for the following year's production and stocks of vegetable and flower seeds were also secured through visits to Sicily and Italy. Seed-cleaning machinery was installed. Brassicas offered the greatest difficulty owing to the freedom with which they cross-pollinate. The possibilities of a seed-potato trade with the Middle East using seed once grown from Scotland, was under investigation. The quality of wine will have to be greatly improved, probably through co-operative wineries, if it is to catch an export palate. Boring at greater depths will have to be continued if irrigation is to be extended. Although extra water was made available from domestic supplies during the war, greater quantities are likely to be required for civilian use and to keep the sewage system flowing. However, purification of sewage and return of the water thereafter to the land would make a big contribution to productivity.

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BACTERIAL CANKER OF TOMATOES IN KENYA

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The "bacterial canker" disease of tomatoes caused by * *Corynebacterium michiganense* (E. F. Smith) Jensen, is widely distributed throughout the world. It was first recorded and described from North America, where it was known, from the locality of the first outbreak, as the Grand Rapids disease in 1909 by E. F. Smith, who named the bacteria causing it *Aplanobacter michiganense*. The disease was reported from South Australia in 1924 and from New Zealand in 1936. In view of the virulence of the disease and the popularity of the tomato, its spread round the world seems to have been comparatively slow. In England it was not recorded until 1942 although it was present in Europe as early as 1929. The first occurrence of the disease recognized in Kenya was near Nairobi in June, 1945. This attack caused the almost complete loss of a small plot at the Scott Laboratories. Dr. W. J. Dowson, to whom a culture of the organism from this plot was sent, confirmed the identification as that of *Corynebacterium michiganense*. As far as is known, this is the first record of the disease in East Africa and it is believed not to have been recorded either from the Union of South Africa or the Rhodesias.

In most countries where it occurs the bacterial canker is considered to be a disease of major importance but its destructive capacity seems to be somewhat variable. In New Zealand, Reid (1938) states that the disease was not then of major importance, while Cunningham (1941) lists it as one of the three major diseases of the crop in that country. In South Australia (Colquhoun and McCarthy, 1943) where the disease is widespread, cankers do not occur and the name Grand Rapids disease is retained. In Kenya, its status is not yet known but judging from the initial outbreak it must be considered capable of causing very serious loss.

The symptoms of the disease vary according to the age of the plant when infected and to conditions during subsequent growth. Young plants may develop a general wilt and die in the seedling stage but in the more mature plants, a general wilt does not usually occur. On these, the symptoms are commonly at first a wilting of the lower leaves which then become rolled, eventually shrivelling and either turning brown or retaining a pale green colour. The effect on the foliage is irregular, one side of the plant being affected while the opposite side may be only slightly affected or not at all. Similarly, individual leaves may have all the leaflets on one side wilted or shrivelled while those on the opposite side remain turgid (Fig. 2). The leaf petiole does not wilt but may turn downwards. A plant may continue for a considerable time with some of the foliage and fruit apparently unaffected. Usually, however, the setting of the fruit is reduced. As the disease advances, an apical wilt develops, arresting further growth (Fig. 1) and leading eventually to the death of the plant.

A distinguishing feature of the disease is the yellow coloration of the internal tissue of the stems, leaf and fruit stalks, seen when these are cut across. This is usually seen as a curved or crescent shaped yellow area, in which may occur reddish-brown flecks, just beyond the pith. In an early stage of infection, this coloration is generally on one side only but later may extend all round the pith. In longitudinal section, it appears as a yellow streak on one or both sides of the pith. This yellow colour can also be seen on the outside of the plant as a streak running up one side and passing into the leaf petioles and fruit stalks. At a later stage, the bark, where the streak occurs, cracks open, exposing the dry puffy tissue below and causing elongated splits or cankers from which the disease derives its name. For the purpose of diagnosis in the earlier stages, a wilted leaf petiole broken or cut away at the junction with the stem will often reveal the characteristic yellow coloration.

The fruit of a primarily infected plant may show no external sign of the disease during early development but the yellow colour can be seen in the placenta and at the scar on the fruit made when it is broken away from the pedicel. When the disease reaches the fruit at an earlier stage, the pedicels may become cankered, causing the fruit to drop or the immature fruits themselves may become stunted or distorted and often of a paler colour than normal.

From parts of the plant where the yellow coloration is in evidence, the bacteria can be

* *Phytomonas michiganense* (Ewr. Smith.) Bergey *et al.*

squeezed out as a yellowish slime. This is sufficient to distinguish the disease from the bacterial wilt caused by *Xanthomonas solanacearum*. This latter organism causes a general wilt with either a brown or no coloration of the vascular bundles and can be squeezed as a whitish slime from the cut stem.

Bacterial canker is distributed mainly by the planting of diseased seed which may be either contaminated from bacteria in the pulp or by internal infection of the seed itself. Bryan (1931) has shown that the bacteria may lie in the fleshy outer seed coat or between the layers of the hard seed coat, at times, in severe infections, penetrating the entire circumference of the seed. The majority of the primary infections are, no doubt, derived from diseased seed. This was probably so in the initial outbreak seen at Nairobi but as over 80 per cent of the plants were infected, there may also have been infection and spread in the seed-bed. It is suggested by Orth (1937) that infected seed acts primarily as a soil-contaminating agent by the decomposition of the seed. Other primary infections arise from planting in contaminated soil more especially in the seed bed. Experiments carried out in Utah (Blood, 1934) gave a figure of 40 per cent to 60 per cent diseased plants from infected seed, 34 per cent from clean seed in a contaminated seed-bed and only 1.3 per cent from clean seed in a contaminated field. Diseased plants left to rot in the ground contaminate the soil with bacteria which, no doubt, can infect young plants in the seed-bed and in the field, but opinion differs as to how far root infection in the field may occur. Ark (1944) was unable to demonstrate root infection.

Most authorities are agreed that the disease can be spread in the field and at transplanting by pruning and handling. The pruning knife is an efficient instrument for passing the disease from diseased to healthy plants. It has been demonstrated (Ark, 1944) that a contaminated knife will serve to pass the disease to as many as 30 plants.

Secondary infection occurs during wet weather. The bacteria exuding from the open cankers may be scattered by rain drops. The symptoms are distinct from the systemic infection and take the form of small raised spots with white haloes on the surface of the fruit. This infection of the fruit is superficial only. No other form of secondary infection has been seen in Kenya.

Since the disease is distributed and perpetuated by the sowing of diseased seed, the most important direct control measure is some form of seed treatment or disinfection. The standard treatment with mercuric chloride will remove the superficial infection of the outer seed coat but is ineffective against the internal infection and gives, therefore, only partial control. Moreover, on account of the poisonous nature of the material it is not generally to be recommended.

Fermentation of the pulp for the extraction of the seed has been found (Blood, 1933, 1937, 1942) to give an almost complete control of the seed-borne infection and to be more efficient than either the hot water (one hour at 54° C.) or the mercuric chloride treatment. In these experiments (Blood, 1937) found that while untreated seed from immediate extraction gave 81.28 per cent of diseased plants, seeds from the fermented pulp gave only 0.188 per cent diseased plants as against 6.18 per cent from the mercuric chloride treated seed. The recommended treatment is to ferment the pulp for from 72 to 96 hours, stirring twice daily to keep the pulp submerged and keeping the mass at, or below, 70° F. In parts of East Africa it may be difficult to keep the mass at a temperature below 70° F. In a trial at Nairobi, the fermenting pulp was kept at a temperature of 90° F. for four days. Although seed from this germinated more slowly, the germination was only slightly below that of the freshly extracted seed.

It has been assumed (Blood, 1937) that efficacy of the fermentation process is due to the presence of the lactic and acetic acids formed. Experiments with these two acids showed that a combination of 0.6 per cent acetic acid and 1.2 per cent lactic acid gave complete control, whereas acetic and lactic acids alone gave 0.08 per cent and 0.62 per cent diseased plants respectively. Further work by Blood (1942) has led to the recommendation, as an alternative to the 96 hours fermentation, to treat the extracted seed immediately by 24 hours' immersion in 0.8 per cent acetic acid or, if the seed is already dried, with 0.6 per cent acetic acid. It would appear possible that the long soak entailed by these two processes enables the acid to penetrate beyond the range of the shorter mercuric chloride treatment. It may here be noted that in the trial at the Scott Agricultural Laboratories, the pH of the pomace kept for four days at 90° F. was 3.8 and that at room temperature for the same period, 4.3. The total

acidity of the former was 14.3 c.c. of N. alkali and 8.4 c.c. per 100 c.c. of pomace respectively. No acetic acid, however, was formed.*

Hutton (1943) has described a method of extracting tomato and cucumber seed by means of mineral acids. It is pointed out that in the extraction methods which employ hydrochloric or sulphuric acid, the pH of the pulp is reduced to 1.2, whereas the minimum pH required to destroy *C. michiganense* is said to be in the region of 1.1, so that to ensure the killing of the bacteria a higher concentration of acid than that recommended for extraction alone would be necessary. It is further pointed out that the killing of the bacteria during the fermentation process must be due to some factor unconnected with the pH of the acids formed during fermentation. Although the mineral acid extraction process may be effective in controlling canker, the fact that the treatment is for 15-30 minutes only would seem to place it in the same category as the mercuric chloride treatment. No account of any experiments to determine the efficacy of this treatment for the control of tomato canker seems to have been published.

The hot-water treatment of the seed, whereby the seed is kept in hot water for 25 minutes at a temperature of 122° F., is stated by Doolittle (1943) to control all seed infection. As the treatment is a very critical one, however, it can hardly be recommended for general adoption.

In addition to seed treatment, other control measures are set out below. Only sterilized soil or soil which has not had tomatoes growing in it before should be used for seed-boxes or seed-bed. Any plants showing symptoms of the disease should be removed and destroyed. No diseased plant material should find its way to the compost heap. As the disease may be spread from plant to plant by pruning, culling the diseased plants should be done before any pruning is attempted or suspected plants should be left until pruning is finished. During pruning and transplanting, the knife and hands should be sterilized frequently.

The most effective precaution is to sow seed only from plants which come from a plot inspected during growth and certified to be free from the disease. If seed from an unknown source is on trial, the seedlings should be raised in isolation away from all other tomato crops until it is seen that they are free from disease.

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* Determinations made by Chemical Section of the Scott Agricultural Laboratories.

The following is extracted from a letter from one of the governments sponsoring this Journal:—

"This Government recommends that the possibility of improving the style of the Journal by avoiding excessive use of technical language should be explored."

In other words *write simply*.

FIG. 1.—A typically infected plant showing rolling and shrivelling of the leaves and wilt of the apical shoot.

FIG. 2.—Leaf of a diseased plant showing affected leaflets on one side only.

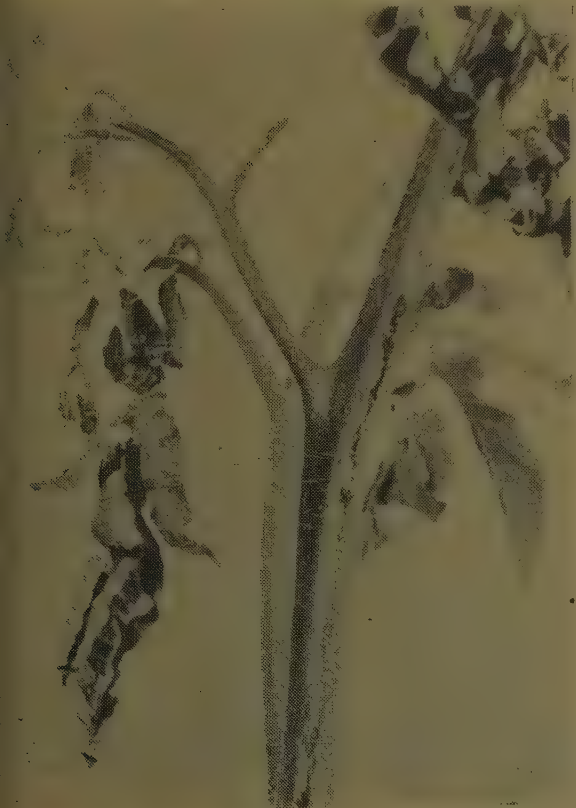

FIG. 3.—Stem of severely affected plant with elongated canker.

FIG. 4.—Stem of tomato plant ten weeks after inoculation, showing canker on stem and flower truss stalk, 50 cm. above the point of inoculation.

NOTE ON THE BACTERIAL WILT DISEASE OF THE POTATO IN KENYA

By R. M. Nattrass, Department of Agriculture, Nairobi, Kenya

(*Received for publication on 2nd March, 1946*)

In an earlier issue of this Journal (Nattrass, 1945), a bacterial wilt disease of the potato was recorded which seemed to differ in many respects from the described symptoms of the disease usually known as Brown Rot caused by *Xanthomonas solanacearum* (E. F. Smith) Dowson.

The symptoms of this disease bore a closer resemblance to those of the Ring Rot, *Corynebacterium sepedonicum* (Spieckermann et Kotthoff) Skaptason and Burkholder, than to those of the typical Brown Rot in that there appeared no discoloration of the vascular tissue in either stem or tuber. Moreover, the bacterial masses exuded from the cut tubers were of a putty-like, rather than a slimy consistency.

Since the publication of the note referred to above, cultures of the organism have been studied by Dr. W. J. Dowson, who reports that the pathogen is an atypical strain of *Xanthomonas solanacearum* and that its effects on the host differ from all other described effects of this species in not staining the vascular tissue in either potatoes or tomatoes. Dr. Dowson also reports some differences in cultural characters.

From inoculations with this organism in Kenya and from general observations, it is evidently very virulent to potato and tomato but not to tobacco. In this respect, it agrees with the strain of *X. solanacearum* in South Africa (Wager, *in litt.*) which also is not pathogenic to tobacco.

Inoculations with the bacteria into tobacco leaf mid-ribs although producing no systematic infection, caused a very slow death of the tissue from which the bacteria were re-isolated 78 days later. The susceptibility of the plants was not increased by keeping them at a temperature of 90 F. but potato plants used as controls wilted after six days at this temperature instead of, as is usual, after 9-14 days.

The isolations of the bacteria from many sources and the inoculations were carried out by Dr. A. Ciccarone.

REFERENCE

Nattrass, R. M., 1945.—A New Bacterial Disease of the Potato in Kenya. *E.A. Agric. J.*, X (3), 162.

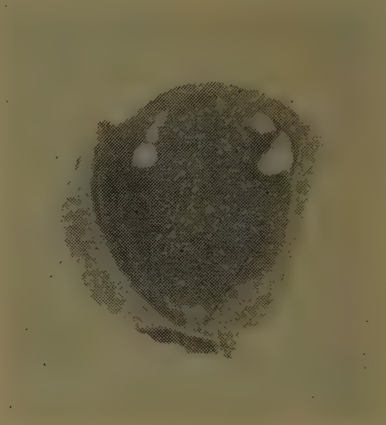

FIG. 1.—Section of stem of potato plant showing the exudation of bacteria but no staining of the vascular tissue. (x 2½)

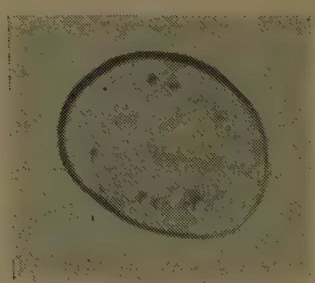

FIG. 2A.—Infected tuber showing no discoloration of the ring.

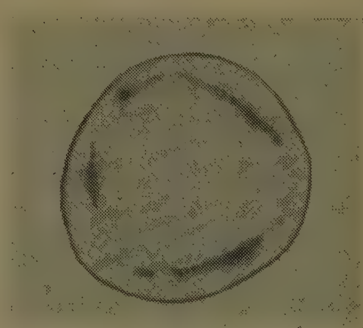

FIG. 2B.—Infected tuber showing normal browning of the ring.

NOTES ON THE HIDES AND SKINS INDUSTRY
PART II

By M. H. French, M.A., Ph.D., A.R.I.C., Dip. Agric. (Cantab.), Veterinary Laboratory, Mpwapwa, Tanganyika Territory

Since the monetary value of the hides and skins industry is determined by the quality of these raw materials, for leather-making purposes, in relation to the value of other sources of the world's supply, it is well to know from what defects East African hides and skins suffer and how these defects arise so that widespread efforts can be made to eradicate the causes and minimize the damage so far as possible. When it is realized that hides and skins are damaged whilst still parts of living animals as well as by the conditions to which they are exposed before, during and after removal from carcasses, it might be thought that the task of improvement is too big or too difficult. Fortunately this is not true because most of the defects and damages could be avoided, and a general appreciation of this important point would do much towards achieving the quality improvement so necessary for the continued prosperity of the industry. It is also true that the greater proportion of the avoidable damage is done during the flaying, fleshing, cleaning, drying and storing of hides and skins, and at least £100,000 are lost annually to East Africa because of carelessness in or ignorance of the correct methods of preparation. Serious though this is, it points the way for effecting improvement in quality and obtaining the quickest financial return for energies expended, namely, education and instruction in the correct methods of preparation followed by a system of marketing which ensures that payment of producers shall always be proportionate to the quality of their products.

In the following pages most of the defects and damages found in East African hides and skins are described so that interested persons may judge their relative importance and take steps to prevent avoidable damage. It will be seen that the main lines of improvement are the elimination of cuts and gouges during flaying, the introduction of proper methods of cleaning, drying and storing, the prevention of delays between flaying, cleaning and drying, the reduction of indiscriminate branding and the replacement of sun-drying on the ground by suspension methods, preferably in the shade.

The defects will be considered roughly in the order in which they operate from the time animals are born until their hides or skins are exported.

Defects Arising From Damage to the Hides and Skins of Living Animals

A. Mechanical origin

A leading South African hide dealer once told me that some of the main defects of East African hides were thorn scratches, brand marks, mange and tick scars. It will be seen that all these originate whlist the hides are still part of living animals and it is well to appreciate how common these defects are and how seriously they can affect the quality of hides and skins and reduce the value of the leathers made from them.

Thorn scratches.—In East Africa the majority of domestic live stock have to seek their grazing in country covered with thorn bush of varying degrees of density. When animals force their way through thorny scrub it is inevitable that their hides and skins will be scratched and there is little that can be done to eliminate this damage other than to graze the animals on open pasturage as far as is possible. Thorn scratches rarely damage the deeper layers of the hide substance but, as the scratch heals, scar tissue is formed in the grain layer which reacts to tannins and dyes differently from the surrounding undamaged grain surface, with the result that the surface appearance of the leather is spoilt. Leather is judged and paid for not only on its prosaic utilitarian attributes but also by its appeal to the aesthetic senses and anything which mars its appearance must detract from its value in the eyes of consumers.

Horn rakes.—Cattle of long-horned breeds are often injured by butts from the horns of their companions but, from the point of view of this article, only the damage to the hide need be considered. Sharp-pointed horns cut into the hide and, as the head of the butting animal sweeps upwards, the hide is scored for a varying length. This damage, like thorn scratches, is confined largely to the grain surface and causes unwanted scar-marks to show on the finished leather, thereby reducing its value. In East Africa damage from horn rakes

is not very common in the hides from short-horned Zebu cattle (except in old bulls scored in many fights) but it is found more often in the higher-priced hides from European animals. The remedy in this case is to de-horn all the animals by rubbing the horn buds with a caustic soda stick during the first week of life.

Sores.—Any injury, wound or sore to living hides or skins results in the formation of scar tissue which reduces the value of the leather which can ultimately be made. If the wound or sore is of a superficial nature the damage affects only the aesthetic value but if the sore or wound penetrates through the hide or skin, the utilitarian value of the leather is reduced, and such portions have to be cut away and wasted. Hides or skins showing sores and wound scars are consequently degraded by purchasers and realize less money than sound hides or skins.

Whip-lash marks.—In work oxen that have been left to careless herdsmen, the backs of their hides are often covered with long scars resulting from abrasions by whip-lashes. Such scars interfere with the surface appearance of the resulting leather and hides damaged in this way are worth much less than sound hides because the damage is nearly always confined to the best portions. The remedy is obvious and lies in the hands of the owner.

Barbed-wire scratches.—Barbed wire and nail scratches are found on hides from some European farms. The scratch marks are often deeper than thorn scratches and so may reduce the tensile strength as well as detract from the general appearance of leather. Obviously these damages reduce the value of the hides and skins for leather production. Wherever barbed wire is used for paddocks it will be found that the cattle rub themselves deliberately on it and much scratch damage is caused by this. The remedy is to erect some other non-scratching type of fence and manufacturers have designed several suitable kinds.

Brand marks.—A very large number of East African hides, which would otherwise be graded and paid for as first class, are relegated to the fourth grade and paid for accordingly because of brand marks. Branding in East Africa is always done by natives, and usually by Europeans, with hot irons; but occasionally Europeans also brand by means of chemicals. Some brand marks are the results of native efforts to combat disease by cauterizing hides in the region of certain glands; more usually brand marks are employed for identification, though, from the extensive patterns on some animals, one speculates as to whether such brobdingnagian brand marks were really intended or whether the artist got carried away by his theme. An extremely wide variety of brand marks are encountered on East African hides, from the gigantic patterns covering the whole of one or both sides of the beast to small letters, numbers or symbols. Also it is not uncommon to find several different brand marks on one and the same hide because the live animal changed hands several times. Much has been said and written by the Veterinary Departments and the hides trade in East Africa against the branding of animals and, though there has been some improvement, much still remains to be done to eliminate or reduce this most common of all damages to hides on living animals.

Because the object is to make an easily distinguishable mark, branding nearly always occurs on the most valuable portions of hides, i.e. the back, rump and thighs. If it is absolutely necessary to brand hides the marks should be made as lightly as possible on the least valuable portions, such as the head, neck and hump, or as low down as possible on the legs, and the brand marks should be as small as is consistent with clarity. Wherever practicable, however, ear-tags, ear cuts, horn or face brands should be employed.

Branding with a hot iron burns the hide tissue and, unfortunately, many brand marks are burnt not only through the surface layers but through the entire hide substance. As the burns heal scar tissues are formed and these cicatrices persist throughout the lives of animals and cause serious damage to the leather eventually made from their hides. If the branding has been light, the grain and upper part of the corium are damaged, but, when it has been deep, the scar tissue penetrates right through and causes weak spots or even holes through the leather. The abrasive resistance and tensile strengths are seriously reduced and such damaged portions have to be cut away to waste because, for example, no one hanging from the end of a leather parachute strap, damaged by a brand scar, would be a position to appreciate the beauty or usefulness of the brand. It is obvious, therefore, that branded hides are worth very much less to a tanner than sound ones, because the transport, commission and tanning charges are the same but the need for discarding all portions, damaged in such a way that they would be of in-

ferior value or dangerous to human life, reduces the tanner's return.

Figures 7 and 8 show the grain and flesh sides of a hide branded in the first place with a deep native pattern and subsequently with a light trader's brand. The deep brand has caused extensive scar tissue on the flesh side but the light trader's brand has not penetrated through. Figure 9 shows the appearance of brand marks on box and suède uppers and on a sole when damaged leathers are made up into shoes.

Too much cannot be said in condemnation of branding as practised to-day in East Africa.

Grass seeds.—In certain parts of the world sheepskins suffer from a defect referred to as "thorn," a condition which arises when small thorns or sharp burrs and grass seeds work their way into the substance of the skin and remain embedded there. These objects, by puncturing the grain and the corium, damage the appearance and weaken the leather and may even remain in the leather after tanning. I have never seen this defect in cattle hides, or in skins from goats and haired sheep, but it does occur in the skins from woolled sheep in East Africa. In adults the defect is confined to the legs and belly, but in lambs certain types of grass seeds caught in the wool over the back, neck and body can work into any part of the skin. Figure 10 shows a lambskin very badly damaged by the seeds of *Aristida adscensionis* grass.

B. Defects due to Disease or Parasites

The live stock of East Africa are exposed to many diseases and parasites which affect the quality of their hides and skins. Since I am not a veterinarian I cannot do more than refer to the causes in the broadest outline and confine my remarks chiefly to the observed defects in the leather.

Ringworm.—This skin disease is caused by a fungal growth which destroys the hair and its roots, inflames the hair follicles, and thereby allows secondary infections to become established. Scar tissues form and the appearance of the resulting leather is marred. If the hide is not removed for some time after an animal has recovered from ringworm the damage to the grain may have disappeared.

Streptothricosis, "upele," sheep-scab, etc.—In these and similar skin diseases of parasitical origin, the hide and skin over the affected area becomes roughened and encrusted. Such hides and skins yield leather with a damaged grain and so are worth much less to tanners.

Tick bites.—Ticks are found over large areas of East Africa and cause a very considerable amount of damage to hides and skins: to the grain surface by the perforations they make when attaching themselves and to the underlying hide tissue when they are sucking. Normally ticks seek the thinner portions of the hide, such as the escutcheon, the dewlap, the inner parts of the thighs and under the elbow, so that their damage is confined mainly to the less valuable portions. The damage shows itself in the form of small more or less healed scars which mar the smoothness of the grain and detract from the appearance of the finished leather. Figure 11 shows tick damage to a cattle hide, whilst the larger perforations indicate where secondary infections became established, leading to far more extensive damage.

Demodectic mange.—This disease is caused by small mites which live in the hair follicles and burrow beneath the skin surface. In its early stages the infestation is difficult to detect and, in a mild attack, it causes shallow, lentil-shaped, depressions on the surface of leather. In advanced cases of infection, the mites accumulate in the substance of the hide or skin in the form of sacks of yellowish, cheesy-looking material. During the progress of the pelt through the tannery many of these sacks burst, when the epidermal layers of the pelt are removed, and the leather then shows a series of holes on the grain surface. Often, after animals have rubbed open one or more of the sacks, secondary infections become established which may lead to pus formation and skin abscesses. When this occurs a much more extensive damage is done to the leather and a hole may result. Figure 12 shows the effects of demodectic mange on a piece of goat leather. Lentil-shaped depressions, holes in the grain and a hole right through the leather as a result of a small skin abscess are seen. In dried hides and skins these accumulations of cheese-like material appear as round yellowish-white spots when the flesh sides are examined. The trade erroneously refers to affected hides and skins as "poxy" and, quite rightly, degrades them because of their lower value to tanners.

Sarcoptic mange.—This skin disease is also caused by mites burrowing under the surface of the skin. The skin becomes irritated, swollen and roughened, and leather from such affected

areas shows a coarse, roughened and broken grain. The damage can be so extensive as to render a skin practically worthless.

Rinderpest.—This febrile virus disease causes emaciation and, as would be expected, hides from animals dying from it are thin and light. No other lesions directly attributable to the disease itself are found on the hides but the poor light hides yield thin sole leather "with thin fibres and little resistance to abrasion". The thinness of the hides may, however, make old scars and blemishes from skin diseases more easily seen, whilst sores and abrasions may develop from struggles after animals have become too weak to stand. In severe outbreaks when many animals die, removal of hides from carcasses may be delayed and the hides consequently damaged by putrefaction before they can be dried. Similar effects would probably be found as a result of the emaciation and weakness from trypanosomiasis.

Hides from animals dying from rinderpest are nearly always sun-dried because quarantine restrictions prevent their transport in the green state and there are usually no shade-drying facilities on the spot.

Fortunately, veterinary activities have now very considerably reduced the ravages of this disease in East Africa and further control measures can, in time, be expected to reduce the deaths from rinderpest to negligible proportions even if they do not eradicate the disease completely.

Anthrax.—Hides from animals dying from anthrax show no defects from the disease itself and are mentioned only because of the dangers associated with the transport and handling of anthrax-infected hides. Man, as well as animals, can contract and may die from this disease. Anthrax spores remain viable for a long time, even in dried hides, so that workmen handling such hides are not only exposed to infection but may, and sometimes do, contract the disease, whilst the transport of infected hides may be the means of spreading the disease in East Africa and also to overseas countries. Carcasses from animals dying from anthrax are, or should be, destroyed together with their hides or skins as the drying and sale of such hides or skins may result in the death of some workman thousands of miles away.

Wholesale vaccination of animals over a number of years would be of immense benefit to the hides and skins trade quite apart from its value in preventing losses in live stock and reducing the risk of infection in man.

C. Defects of Nutritional Origin

Starvation.—Periods of under-nutrition alternate with periods of plenty for the majority of native-owned stock in East Africa. Good feeding tends to build up the hide substance whilst starvation has the reverse effect. At the end of a long dry season, when food has been scarce, hides and skins are thin and light and yield a lower quality leather than when the animals and their hides or skins have been built up by luscious grazings.

Defects in Hides and Skins Arising from Damage Associated with Slaughtering, Flaying, Cleaning and Drying

Bruises.—Unnecessarily hard beating of animals with sticks and ropes when driving them to slaughter causes bruises on the meat but also leads to blood extravasation in the hide or skin over the bruised area. The smaller blood vessels become ruptured and the flesh side of the fresh hide or skin appears red. Unless the hides and skins are carefully cleaned and dried, without delay, these local accumulations of blood will quickly putrefy and cause blemishes or weak spots in the final leather.

Similarly when animals are thrown preparatory to the Mohammedan method of slaughter, bruising often occurs if they are allowed to fall heavily on concrete floors. Bruising also happens if animals are driven so that they jam in doorways or are knocked by their companions against the walls of the holding pens at slaughterhouses. Every effort should be made to avoid bruising immediately before slaughter because not only is the risk of putrefaction increased but the grain surface of the hides and skins may be damaged by abrasions and cuts.

The provision of properly constructed "hunger-pens" with smooth walls and rounded corners, adjacent and joined to the slaughtering floor by a short corridor, with smooth cement walls, would be of great help in preventing unnecessary driving and bruising of slaughter animals. The much wider use of humane killers for stunning animals would go a long way towards eliminating the rough handling of animals in slaughterhouses.

Dragged grain.—If carcasses are dragged over rough concrete or other sharp edges, the hide or skin surface may be scratched. Though this damage may be only superficial it does prevent the preparation of first-lass leather and is a defect that can be easily avoided by the proper use of hoisting tackle in abattoirs.

FIG. 7.—A deep native and a light trader's brand as they peared on the external surface of a dehaired ox hide.

FIG. 8.—The inside appearance of the hide shown in Fig. 7. The deep native brand has caused the formation of much scar tissue whilst the light trader's brand has not burnt through.

FIG. 9.—The suède upper, sole and box upper leathers these shoes were made from branded hides. The un-ghtly brands mar the appearance of the shoes and makes em unsaleable.

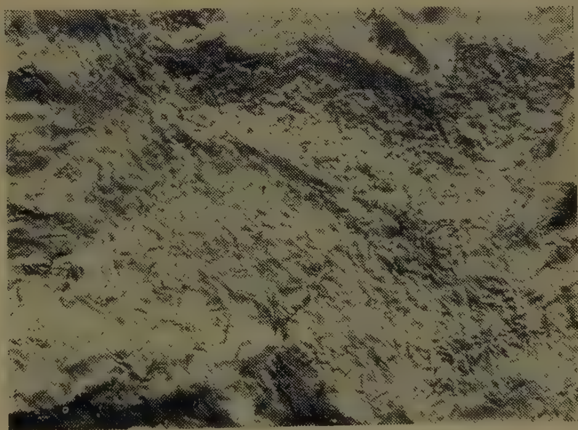

FIG. 10.—Interior surface of a skin taken from a lamb which was dying from the irritation caused from the penetration of its skin by the seeds of *Aristida adescensionis* grass.

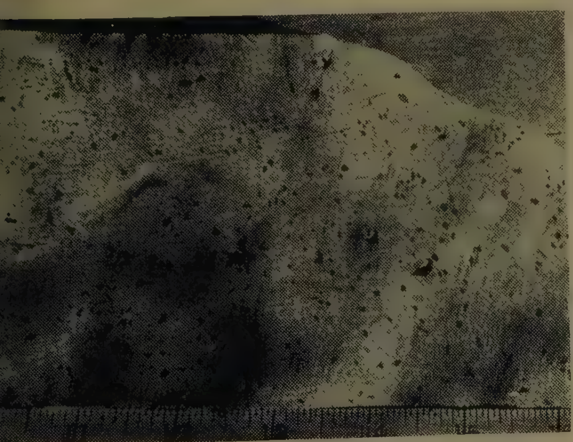

FIG. 11.—Blemishes on leather, made from a cow hide the result of tick bites. The larger holes are caused secondary infections which developed into small skin scesses.

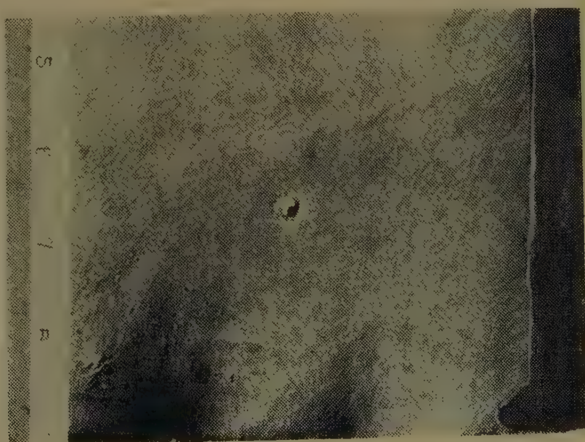

FIG. 12.—A piece of goat skin leather showing the small grain perforations resulting from Demodectic Mange. The large hole indicates where a small skin abscess had developed.

FIG. 13.—The "veiny" appearance of leather made from the skin of an animal which had not been bled out properly. Bacterial action along the course of the blood vessels has resulted in open channels of decomposition through the leather substance.

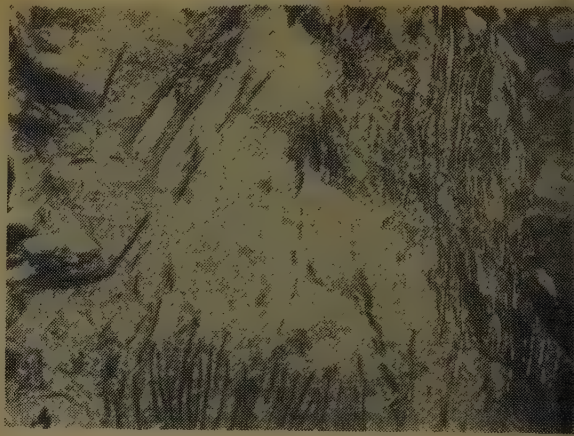

FIG. 14.—The inside of an ox hide showing considerab damage from gouging by knives during its removal fro the carcass.

FIG. 15.—The appearance of leather from an ox hide which had been dried in contact with the ground. The trade name for this type of bacterial damage is "taint".

FIG. 16.—A piece of leather made from a "blistered sun-dried ox hide. Bacterial action along the central laye has resulted in the splitting apart of the two outer layer of leather.

FIG. 17.—A sun-dried goat skin after passage through a tannery. The damage during sun-drying was so extensive that a considerable proportion disintegrated in the tannery to leave a completely useless piece of leather.

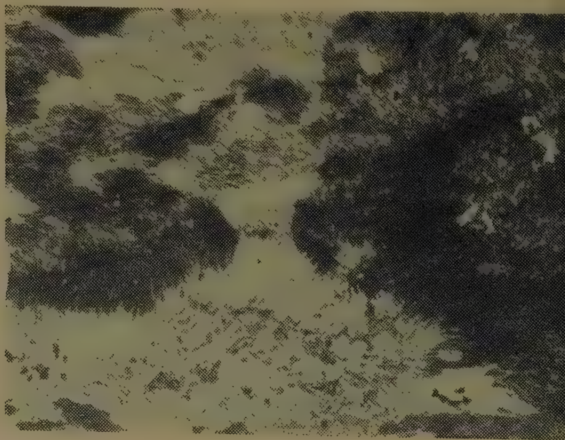

FIG. 18.—A calf skin showing bare patches and hol caused by the activity of *Dermestes vulpinus* larvae.

Inadequate bleeding.—If carcasses are not bled-out completely at the time of slaughter, blood remains in the vessels and capillaries of the hides and skins. If cleaning and drying are delayed, bacteria may develop more rapidly along the blood vessels than through the substance of the hide or skin. As a result of bacterial spread from the blood vessels, hide and skin fibres in their vicinity are destroyed and open channels, following the course of the blood vessel, are formed through the hide or skin substance. Leather made from hides and skins damaged in this way shows shallow grooves on the grain surface following the pattern of the damaged blood vessels. This defect is referred to as "veiny" leather and is illustrated at Figure 13.

Unfortunately this defect cannot be seen in the dried hide and only becomes obvious as the leather is finished. It is not likely to occur where Mohammedan slaughtering is done and where hides and skins are cleaned and dried straightaway. It is more likely to occur when animals die a natural death or when game animals are shot.

Bad pattern.—The correct method of opening up a carcass has already been described in Part I. No deviation from these lines should be permitted otherwise the final shape will not be symmetrical. This may not appear a very serious matter since the shape of hides and skins cannot affect their conversion into leather; but pattern does seriously affect the usefulness of hides or skins for the production of commercial leather of recognized grades. As will be discussed in Part III, hides and skins are not uniform in structure over the whole body and some portions such as the belly are much less valuable than the butt. Where, as in heavy cattle hides, the distinction in usefulness between the different portions is more marked, it is most desirable that the pattern should conform with the one which has been proved, by many years of experience, to be the most economical for cutting and use. Also, since the belly area is thinner than the back there is a greater tendency for this portion to stretch and become distorted if it forms a single sector of the hide or skin than when it is distributed evenly on the outside of the pattern. Also holes have to be made in hides and skins for suspension drying (or even for pegging out) and it is most desirable that the holes should be in the least valuable portions.

Delay in cleaning and drying.—Hides and skins become smeared with blood when animals are slaughtered and since this is an extremely good medium for bacterial development, any delay in washing off blood, dung or mud increases the risk of surface putrefaction and damage to the grain. Such surface putrefaction causes damage to the hide proteins so that the grain layer disappears during the tannery operations and the appearance of the finished leather is spoilt. This damage is usually not apparent in dried hides and skins but only appears when the latter leave the lime pits and so should be guarded against most carefully because damage of this kind depreciates the reputation of *all* hides and skins from an area and leads to low prices if tanners again risk buying from there.

Delay in cleaning also leads to putrefaction in the interior of hides and skins which results in damage to, and disintegration of, the fibres and causes the final leather to be looser in structure and more porous. In certain cases, the bacterial damage appears concentrated in the sweat-gland layer, i.e. between the grain and the main substance of hides and skins. In these cases large portions of the sweat-gland layer may disintegrate and disappear in the tannery and, in the final leather, the grain is loose or "pipey." Surface putrefaction also occurs in areas not fouled by blood and leads to the same type of grain defect as occurs where blood has been left. As in the case of blood putrefaction, this kind of putrefaction is not visible in dried hides or skins unless it has been sufficiently extensive to cause a loosening of the hairs so that they rub off and give rise to the term "hair-slip." Any evidence of hair-slip results in serious de-grading of the hides or skins because the buyer knows some putrefaction has taken place but he does not know how extensive it is and so must safeguard himself against loss. If the delay in cleaning and drying has been unduly prolonged, the putrefactive damage may be so serious that the hides and skins fall to pieces in the tannery beam-house processes.

Gouge marks, cuts and holes.—Attention has already been drawn to the extensive damage done to the industry from the gouges, cuts and holes made in hides and skins during their removal from carcasses and during removal of surplus flesh and fat, and suggestions have been made for avoiding these damages. There is no need to enlarge upon the effect of holes in a piece of finished leather beyond remarking that there is always a certain amount of sound leather surrounding the hole which cannot be used because of the impossibility of

fitting in the leather shapes to be cut. In the case of cuts and gouges, the substance of the hides and skins has been cut through but not so completely as to make a hole. They not only give the flesh side of the final leather an unsightly appearance but seriously reduce the tensile strength and abrasive resistance and subject the leather to dangerous failures.

Gouging is extremely prevalent in East African hides but, by proper care, could be almost entirely eliminated, with enormous benefit to the reputation of the local products and an appreciable increase in the revenue from the industry. Figure 14 shows gouge marks on a cattle hide and it is not hard to imagine the reaction of a tanner to damage of this kind.

Bad trim.—There is no excuse for failure to trim off untidy, useless pieces from the edges of hides and skins. These only increase the weight but have to be removed later, as they are useless from a tanner's point of view. Hides and skins regularly sold with tails, dewlaps, long shanks and useless small portions jutting out from their main outlines are obviously worth less to the trade than properly trimmed hides and skins. An area with a reputation for bad trim therefore is paid for its products at a lower rate than would otherwise be the case.

Blood, dung, and dirt.—Hides and skins dried with blood, dung and dirt on them are straightaway de-graded when they come on the market. Not only do these substances increase the weight fictitiously but they are likely sites for putrefactive damage to the grain. As already stated, and this cannot be over-emphasized, all hides and skins should be thoroughly washed before drying.

Taint.—As already discussed, the word "taint" means putrefactive damage to the grain surface caused by retarding the rate of drying. It occurs when hides and skins are dried in contact with a solid object, which prevents air from circulating freely over the surface, and is found when hides and skins are dried (*a*) in contact with the ground, (*b*) hung over a pole or (*c*) when part of a suspended hide is dried in contact with the frame. Putrefactive organisms damage the grain and sometimes the deeper layers, with the consequent appearance of blemishes and even holes in the finished leather. Taint also occurs when hides and skins are suspended for drying in an atmosphere so humid that they dry extremely slowly. It is impossible to predict the extent of the damage done until the hides and skins are going through a tannery but, when buying a second lot from an area which has given such tannery losses, the price is reduced to take care of any further losses which may occur. Figure 15 shows the appearance of a piece of leather made from a tainted hide.

Hair-slip.—Hair-slip is but an indication of putrefactive damage to the grain surface which has so loosened the hair that it rubs off easily.

Blister.—As mentioned in Part I, "blister" is a trade term for putrefactive damage to the central layers of sun-dried hides which results in the disintegration of this layer in the tannery and leaves the two outer layers split apart. Figure 16 illustrates this damage in a piece of leather. Damage of this nature results from the too rapid drying of the outside layers of hides so that a moist central layer is contained between two "case-hardened" outer layers which do not permit the passage of moisture from the central layer outwards. This damage can be eliminated by suspension drying in the sun or by shade-drying.

Sun-drying.—Sun-drying on the ground is here listed as a defect because, as enumerated in Part I, this method of drying leads to many serious faults. Figure 17 shows what may happen to a sun-dried goatskin during its passage through a tannery.

Overstretching and distortion.—When hides and skins are laced to a frame for drying they should be under light tension just sufficient to stretch them to their normal shape. If they are too tightly laced to the frame, they come under great tension as they contract on drying and this causes undue stretching of the thinner portions and a rupturing of fibres. Naturally this yields a leather of lower breaking strength and looser structure where the ruptures have occurred. If the lacing rope is too tight in one direction only, the shape of the hide or skin is distorted and the selling price is lowered.

Folding.—If hides and skins are folded, as soon as they leave the drying-frames, down the line of the back-bone, they apparently suffer little damage. If they are allowed to become flint dry before folding there is a danger that fibres will be ruptured and cracks develop in the leather as the result of rupturing the grain.

Rubbing with stones when dry.—I have seen goatskins very badly scored on the flesh side because natives had attempted to rub off with stones the surplus flesh and fat after the skins had been dried. This should never be done, as

some of the score marks penetrate deeply into the corium and weaken the resulting leather.

Defects of Hides and Skins Arising from Damage During Storage and Transport

Rubbing during transport.—Dried hides and skins are hard, rigid objects so that dragging them over hard, sharp surfaces may score them and thereby lead to defects in the final leather. Also, during transport on lorries or trains, hides and skins may jog up and down against a hard, sharp object so that the substance is frayed away. Even if a hole does not actually develop the damage done will seriously reduce the utilitarian value of the resulting leather.

Wetting.—If dried hides and skins become wetted during storage or transport, conditions immediately become favourable for putrefactive organisms to start work. Usually when hides or skins are wetted during storage or transport, the fact is not realized immediately, or it is not possible to take immediate steps to dry out the wetted portions, with the result that considerable damage may occur. Instead of trying to discover any wetted hides and skins so that they may be dried at once, it is far better to ensure that the storage or transport conditions are such that wetting cannot occur. Experienced hide-selectors can pick out the worst cases of such damage and de-grade accordingly.

Vermin damage.—Hides and skins during both drying and storage are liable to damage from vermin. Hyenas and jackals will tear a hide or skin to pieces if they can find one, whilst rats will nibble and spoil any that take their fancy, particularly those with tasty lumps of meat or fat left on them.

Insect damage.—White ants will eat holes through hides and skins and can render them useless for making leather. Hides and skins are also damaged during storage in the dry state by the hide beetle (*Dermestes vulpinus*) and the hairy larvae of these insects cause more damage than the adults. The insects and their larvae fed on both sides of hides and skins. Since the fatty areas are particularly attractive on the flesh side removal of excessive fat is an aid to preservation. On the hair side, the ravenous larvae eat away the grain surface and spoil the appearance of the finished leather. In some cases, the damage is sufficient to result in holes through skins. Figure 18 shows damage due to hide beetles, i.e. loose hair, removal of grain layer and holes. The larvae of Tineid moths cause similar damage to stored hides and skins. Treatment of hides and skins with sodium arsenite or sodium silicofluoride preserves them against insect attack but, for short periods of protection before sale to exporters, pyrethrum, derris or naphthalene powders can be used.

Rat, bat and bird manure.—Hides and skins are sometimes stored where they become fouled by the droppings of rats, bats and birds. This should never be allowed to happen.

Used hides and skins.—It often happens that hides and skins are offered for sale after they have been in use for some time as native sleeping mats. They have usually been softened by repeated bendings and may have undergone extensive rupturing of their fibre structures. They can only be bought at the cheapest rate.

Smoke stains.—Hides and skins are sometimes stored in smoky native huts or may be placed near smoky fires to hasten or complete their drying. Such hides and skins become smoke stained and are placed in the lowest grade and paid for at the lowest rate. This is because smoke not only stains with its tarry compounds but also tans because of its aldehyde content. As the hides and skins are both stained and partly tanned, the normal tannery operations are interfered with and the appearance and quality of the final leather impaired.

(*To be continued*)

One can no more produce fundamental and truly original work by means of some grand over-all planning scheme for science than one can produce great sonnets by hiring poets by the hour.

Despite a vast amount of loose enthusiasm, much of which hides vaguely behind military secrecy, over the "advances" of science during war, the sober fact is that the great bulk of scientific work during war consists of rushing through, with feverish haste and often with highly inefficient but necessary extravagance, the practical application of basic scientific knowledge which has been gained in the past.

Dr. Warren Weaver,
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THE EUCALYPTUS WEEVIL IN EAST AFRICA

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The native home of the Eucalyptus Weevil (*Gonipterus scutellatus*, Gyll.) recently introduced to Kenya is Tasmania whence it was originally described (Gyllenhall, 1833), and the Australian mainland where it is well known (Lea, 1927), although it does not constitute a menace to gum trees and is, in fact, an uncommon insect. Later it was introduced to New Zealand, where it became a pest of considerable importance (Miller, 1927).

Some time prior to 1916 the beetle was introduced into South Africa (Mally, 1924). The weevil spread rapidly after 1925 over almost the whole of the Eucalyptus-growing area of the Dominion and eventually reached Nyasaland (Smee, 1937) and Portuguese East Africa (Smee, 1938). So far, however, it has not been reported from the Rhodesias or Tanganyika, but on the 14th November, 1944, a previously unknown pest, causing damage to thousands of acres of *Eucalyptus globulus* was reported by the Agricultural Officer at Kericho. This proved to be *Gonipterus scutellatus* (Wilkinson, 1945).

Judging by the extent of the damage, the beetle had been present in Kenya since some time prior to 1941 and was presumably introduced from South Africa by air at Kisumu. The beetle was also found in Eastern Uganda shortly afterwards (January, 1945) as a result of a warning being given to that country.

Immediately on confirmation of the identity of the pest by the British Museum (1st February, 1945), Mr. H. Wilkinson, Senior Entomologist, made arrangements to visit South Africa to obtain all available information regarding the beetle, and to arrange for the introduction of the parasite, *Anaphoidea nitens* Gir. As a result, the parasite was introduced into Kenya within a remarkably short time. The first of four consignments from South Africa was received in Kenya on the 14th March, 1945, four months after the first notification of the pest and only six weeks after the beetle had been identified.

Description of Weevil

An account of the Eucalyptus Snout Beetle is given by Mally (loc. cit.) and is briefly as follows:—

The Adult Beetle.—The adult beetle is about one-quarter of an inch long and about half as wide. It is a typical weevil in appearance, having a very convex dorsal aspect and a blunt snout. It is easily recognizable by its powdery "bloom" and characteristic markings. The background is light reddish-brown or greyish-brown with dark brown markings on the head and sides of the thorax. The elytra or wing cases are dark brown except for a small central light mark anteriorly and a large triangular light patch extending from near the centre-line to the margin of each elytron.

The Larva.—The grub is legless and slug-like in appearance, bright yellow-green with a dark lateral stripe on each side, and studded with small black dots. Fully grown it is about half an inch long and sticky to the touch. The faeces of the larva are characteristic and form a long, black curling pipe which remains attached to the larva for a considerable time.

The Eggs.—The eggs are laid on very young leaves in batches of 5–13, averaging nine at a time, and are covered over with a hard rough outer covering consisting largely of faeces. This capsule is black when young but later becomes sepia-brown. It is slightly longer than it is wide, being about three millimeters in length. The yellow eggs inside are less than one millimeter long.

Life History

The life history of the weevil in Kenya is as yet incompletely known.

The egg-capsules are laid on the very young leaves and occasionally on the shoots. The eggs probably take about ten days to hatch and the young grubs eat their way out through the leaf or occasionally prise up the edge of the capsule so that, in either case, the capsules appear to be intact after the larvae have left them. The larvae then attack the surface of the foliage, eating narrow slits in the epidermis and after some weeks drop from the trees to pupate in the ground.

The pupal stage lasts about a month, after which the adults emerge to attack the trees and to lay eggs.

There does not appear to be a definite resting period in Kenya and breeding is probably continuous, although there are certainly periods of greater activity which seem to vary from district to district.

The beetle is a strong flier, which accounts for its rapid spread when introduced to a new country.

Damage

Both adults and larvae cause considerable damage to trees.

The adult feeds mostly along the edges of the leaves, giving them a scalloped appearance and young growth may be almost denuded of leaves. The soft bark of young shoots may also be attacked and these become deeply pitted, with serious consequences for the young leaves and shoots of leaders. The leaders themselves may even be girdled and killed by the gnawing of the beetle.

The damage caused by the larvae, however, is far more serious. All the epidermis of the young leaves may be eaten and only the hard fibres remain and these become brown and dry.

The first symptom of attack is a brown, scorched, denuded appearance at the tops of the trees.

The destruction of the soft twigs and foliage causes the production of shoots from the lower buds. These are destroyed in turn and the lower branches become exposed, with a result that tufted growth occurs which is again destroyed and older and older wood is forced to produce new shoots.

In a few years the tree becomes stunted, with clusters of dead growth along the branches, and eventually ceases to increase in thickness and may even split and die.

Where plantations are cut down, the coppice growth never attains any great height before it is easten down again, resulting in dense stunted bushes of a few feet high. The same is true of attempts to establish new plantations of susceptible species and there is little hope of obtaining timber without control measures being taken (Wilkinson, loc. cit.).

The beetle thus presents a very real threat to East Africa, since the Kenya and Uganda Railways, the pyrethrum growers and the very important tea industry depend very largely on Eucalyptus for fuel, while very considerable quantities of susceptible species of Eucalyptus are cut annually for fuel in the plantations of the Kenya Forest Department.

Host Plants

The Eucalyptus Weevil is confined almost entirely to gum trees and is not known to attack any other plant except apple. The attacks on apple, however, are not of a serious nature, although slight damage to fruit is reported by Lea (loc. cit.) in Australia and Miller (loc. cit.) in New Zealand. The beetle has not been reported on apple in Africa. All species of Eucalyptus are not attacked equally severely and some appear to be entirely immune. An account of the susceptible species of Eucalyptus in South Africa is given by Mossop (1926) and Tooke (1935) and in Nyasaland by Smee (1937).

Of the very large number of Eucalypts grown in East Africa, the most important susceptible species are *E. globulus*, *E. maideni*, *E. robusta*, and *E. smithii*. Several species are only damaged in unfavourable localities, while *E. saligna* and others are only slightly attacked. Many species, including the commonly grown *E. citriodora*, are apparently immune.

Distribution in East Africa

The Eucalyptus Weevil had apparently been present in East Africa for several years before it was first reported from Kericho in November, 1944, planters having been previously under the impression that drought and poor conditions were the main causes of the damage they had noticed.

Shortly after the discovery of the beetle, a survey was made by Mr. H. Wilkinson and Mr. C. F. Fox, who discovered it to be present at Kisumu, whence it was thought to have spread to Maseno and Tororo in the north-west, Kisii in the south, Sotik and Kericho in the south-east, Lumbwa, Londiani, Mau, Molo, Turi and Elburgon in the east.

Since then it has been reported from Mbale (Uganda), Lower Kabete, Upper Kiambu, and Lower Limuru, Nairobi, Ngong, Turbo and Kitale, and is probably present in many other places.

Control Measures

In South Africa, where the beetle became a menace to all susceptible gum trees throughout the Dominion, it was found that all measures other than biological control were either useless or economically unsound and in 1926, following a search in Australia by an entomologist of the South African Government, a minute wasp-like Mymarid egg-parasite, *Anaphoidea nitens* Gir., was discovered and introduced (Mossop, 1927A).

Seven native South African species of sucking bugs also attack the beetle grub to some extent (Mossop, 1927) but their importance can be discounted in view of the success met

by the introduction of the wasp, which became established almost at once (Mossop, 1928 and 1929) and has subsequently made such good progress that it has controlled the beetle in all the main Eucalyptus-growing areas and the only serious damage now occurring is in areas where conditions of soil and rainfall are unfavourable to the growth of the trees (Tooke, 1942).

The parasite is also present in Nyasaland (Smee, 1937) and has been introduced to New Zealand (Miller, loc. cit.).

Introduction of *Anaphoidea nitens* to Kenya

The parasite was introduced to Kenya four months after the first report of damage as a result of Wilkinson's visit to South Africa, the Union Government being most helpful and co-operative in every way.

Four consignments of parasitized egg-capsules were received by air between the 14th and 19th of March, 1944, and these were all released by the 29th March. The original releases were made in Kericho District at Chemagondi, Kitumbi, Kaisugu, Kenya Tea Co., Kericho Township, and Jamji; in Sotik at Bessabey, Arroket and Dooner's Bridge; and also at Kisii.

Subsequent search for the parasite in the release areas by Wilkinson and Fox proved unfruitful, and it was not until the 23rd of May that recoveries of the parasite were made in the field by Lt.-Col. Brayne of Kaisugu, Kericho, where it had become well established.

Material forwarded from Kericho to the Scott Agricultural Laboratories was bred up and further releases of the parasite were made in the Mau–Molo–Turi area in August and September. Later, when the parasite had become thoroughly established, material from the field allowed further liberations to be made in the Mau–Molo area (where confirmation of the establishment of the parasite was lacking), in the Kisii and in Maseno (November, 1945). It has not been necessary, therefore, to import any further consignments of the parasite from South Africa.

Life History of *Anaphoidea*

The life history of *Anaphoidea nitens* in South Africa has been described and figured by Mossop (1927 and 1929) and is as follows:—

The parasite is a minute wasp-like insect not much more than one millimeter in length. The female mates almost as soon as it emerges from the pupa and at once proceeds to seek out the egg-capsules of *Gonipterus*. On finding a capsule, the tubular ovipositor of the parasite is inserted through the capsule and into the eggs of the beetle, where the tiny curved eggs of the parasite are laid. The female continues to lay for 10 to 15 days although most of the laying takes place in the first two or three. The eggs of the parasite hatch and commence to feed on the developing *Gonipterus* embryo which is devoured entirely. When the parasite larva is fully developed it pupates inside the host egg and the adult *Anaphoidea* eventually emerges through a small round hole gnawed in the upper side of the capsule. The whole process from egg to adult takes from 19 to 33 days in Kenya, averaging about 21 days in the laboratory.

Parthenogenesis (egg-laying by unmated females) had not previously been recorded but Fox has shown that it can occur, the off-spring of unmated females being male. It is unlikely that it occurs frequently in the field since mating takes place almost at once.

Recognition of Parasitism in the Field

To determine whether the parasite is present in the field, a reasonably large sample of young capsules is collected and kept in tubes. If the material is parasitized, the wasps will emerge into the tubes within about three weeks. This is the most certain method of determination, but an examination of capsules in the field is often sufficient to tell whether the parasite is present. Old capsules from which parasites have emerged will show the tiny exit holes of the wasp and an examination of young capsules will often show the black forms of almost fully developed wasps inside the individual eggs. The larvae of the wasp, however, are not evident without a microscope although young pupae may sometimes be identifiable by the small reddish eye-spots showing through the weevil's egg at the anterior end.

Rearing and Distribution of Parasites

The methods of rearing in the laboratory and of distribution of the parasite in South Africa have been described by Mossop (1929) but in Kenya they did not prove very satisfactory and alternative methods were devised by Fox who carried out the work of rearing the parasite.

Daily collections of egg-capsules were made from a nearby source, both from the field and from specially grown susceptible seedlings. The capsules on their pieces of leaf, up to 50 to-

gether, were then placed in tubes into which a number of the adult *Anaphoidea* were introduced, depending on the numbers available at the time. A small drop of honey and water was smeared on the side of the tube as food. The parasites were introduced to fresh capsules daily for 15 days. A second tube was then placed over the mouth of the first and secured to it by a piece of rubberized tape.

Site examined	Number of capsules examined	Number of capsules parasitized	Miles from nearest liberation site
MOLO AREA—			
Molo A	28	Nil	0
B	32	Nil	0
C	50	Nil	0
D	No sign	of weevil	
Mau-Molo ..	30	Nil	0
Turi	8	2	Nearby
Londiani	20	Nil	14
KERICHO AREA—			
Kericho A ..	86	35	0
B ..	15	6	¾
Kaisugu	202	74	0
Mau Forest Estate	52	13	1½
K.T.C. Estates ..	158	76	0
Chemagondi A ..	69	27	0
B ..	8	4	1
C ..	31	15	½
D ..	No count	Parasite present	1
Kitumbi A ..	21	7	0
B ..	35	25	½
C ..	No count	Parasite present	½
D ..	45	25	2
E ..	No count	Parasite present	3
Jamji A	39	25	0
B ..	5	3	¼
C	30	2	3
Maramura.. ..	No count	Parasite present	4½
SOTIK AREA—			
Dooner's Bridge A	No capsu	les found	0
B	100	2	0
Arroket A ..	50	8	0
B ..	30	8	½
Bessabey	21	2	0
KISII AREA—			
Kisii	No capsul	es seen, all	0
	young g	rowth cut	
Iriria	40	10	5½

When the resulting generation of parasites had emerged, the two tubes were orientated so that the empty one was towards the light, and immediately almost all the wasps which had emerged, entered it and thus were captured without handling.

Stocks of parasites were built up in this way until sufficient had been bred to allow liberations in the field.

The material for liberation consisted of adults in tubes which were dispatched to the releasing sites. In this way the method differs from that used in South Africa where parasitized capsules are dispatched in boxes from which the adult wasps emerge as their development is completed in the capsules.

SPREAD OF THE PARASITE IN KENYA

In October, 1945, the writer made a survey of almost all the liberation sites to determine the extent to which *Anaphoidea* had become established. The results are given in the table. It should be noted that the investigation was made with a view to determining only the presence or absence of the parasite, and observations were made only with a hand-lens in the field, so that only pupae of *Anaphoidea* could be observed. In consequence, the absence of the parasite is not assumed where negative results were obtained.

It will be seen that even by October, 1945, the parasite had, in some places, spread up to 5½ miles from its original liberation site and in certain areas attained a very high percentage parasitism. Since this survey was made, the parasite has also become established at Molo and has been recovered over a traverse of many miles near Londiani, at a very considerable distance from the nearest liberation.

EFFECT OF THE PARASITE IN KENYA

The results of the introduction of *Anaphoidea* to Kenya will probably not become fully apparent for two or three years, but in Kericho District, where the parasite has become successfully established, the general consensus of opinion among planters in October, 1945, was that a considerable improvement in the growth of gums had occurred already.

There are insufficient data to prove that this was due to the parasite and not merely seasonal, but at Kaisugu, at least, the parasite may have been responsible for the improvement, since the recovery of trees seems to have progressed steadily from old liberation sites to the newer ones.

Thus, although it is still too early to make any definite predictions, the results to date augur well for the future.

The work has now been handed over entirely to the Forest Department since the appointment to Kenya of a Forest Entomologist.

SUMMARY

The Eucalyptus Weevil was first noticed in East Africa in November, 1944, and by March, 1945, the Mymarid parasite *Ana-*

phoidea nitens had been introduced from South Africa.

A description of the weevil, its life history, and the damage caused by it are given.

The beetle presents a very real threat to the economy of East Africa.

The more important species of Eucalyptus grown in Kenya and their susceptibility to attack are given.

The present distribution of the Eucalyptus Weevil in East Africa is noted.

The introduction of *Anaphoidea* to Africa with particular reference to East Africa is mentioned and the areas where the parasite was liberated in Kenya are given.

The parasite was recovered in the field in May, 1945.

The life history of *Anaphoidea* is briefly described and the method of determining the presence of the parasite in the field is given.

Mass rearing in the laboratory is briefly described. This has been discontinued since material for distribution can now be got from the field.

The parasite had, by October, 1945, already become well established and in some areas a very high percentage parasitism had been reached. It would appear that some improvement has already occurred in certain plantations and the prospects for the future seem good.

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WRITE SIMPLY

They said: Sprouting and water-uptake are accompanying and non-separable phenomena.

Try: Sprouting and water-uptake always go together.

They said: There are difficulties in the way of purchasing adequate quantities of cereals.

Try: It is difficult to buy enough cereals.

They said: Such large proportions have now been assumed by this office . . . .

Try: This office is now so large . . .

They said: In 1945 adverse climatic conditions effected a decrease in the cotton crops.

Try: In 1945 the cotton crop was reduced by unfavourable weather.

They said: Cases of localized failure of the parasites have been occurring.

Try: There have been local failures of the parasites.

They said: Pupation occurs in a naked condition.

Try: The pupa is naked.

They said: When the emergence of the parasite is a *fait accompli* the host succumbs after a limited period.

Try: The host dies soon after the parasite emerges.

They said: The birds exercise a strong biological attraction for each other when brought together artificially.

Try: The birds mate readily in captivity.

A SHORT ACCOUNT OF THE KILIMANJARO NATIVE CO-OPERATIVE UNION, LTD.

(*Received for publication on 8th February*, 1946)

The Kilimanjaro Native Co-operative Union, Ltd., has its fourteenth birthday this year and is now firmly established as an essential part of the organization of one of the most progressive tribes in East Africa—the Chagga. The Union has passed its formative stage and the following is an endeavour to show its progress.

The history of the Chagga tribe shows that they are composed of elements of six main tribes: the Kamba, Teita, Masai, Pare, Kahe and Shambaa, who settled in the forest slopes of Kilimanjaro some 200 years ago possibly to escape from internecine warfare within their own tribes. The community sense, which is such an important characteristic of Africans, was confined within the separate tribal clans, who fought with each other until European advent provided stability. The traditions of the leaders was towards separatism, isolated as the clans are by mountain ridges and ravines, and it has been through economic need rather than social desire that these various elements have become homogeneous. European settlement was chiefly responsible for bringing the Chagga together and the development of a single economic crop by both Africans and Europeans living side by side still further emphasized the need for a communal front.

The chief economic crop is arabica coffee, some 4,000 to 5,000 tons of which are produced annually on Kilimanjaro; 75 per cent by Africans and 25 per cent by Europeans. The plantings extend over some 800 square miles, mostly on the well-watered southern slopes of the mountain at altitudes varying between 4,000 and 5,500 feet, and with a rainfall between 60 and over 100 inches. Coffee seeds were first planted in 1893 at the Roman Catholic Mission at Kilema, and by 1916, Africans owned some 20 acres. The affluence of their European neighbours was attributed to coffee and this encouraged the Chagga to increase their plantings so that by 1925 some 4,500 growers owned about 1,500 acres and produced 80 tons. At that time there was considerable opposition from Europeans towards African coffee growing as it was feared that it would become a source of danger from pests and diseases. This opposition encouraged the Africans to form an association to protect their interests, which was known as the Kilimanjaro Native Planters' Association. The association remained in being until 1932 when its assets were taken over by the Kilimanjaro Native Co-operative Union, Ltd., which was registered as a co-operative society under the Co-operative Societies Ordinance of 1932.

On the formation of the co-operative movement on Kilimanjaro in 1932, the Chagga coffee industry comprised some 12,500 growers owning 6,400 acres producing about 1,000 tons of parchment coffee. In the Union's first annual report it stated that the strengthening of the primary societies was one of the chief aims, and that the establishment of local head quarters for them, the marketing of other crops besides coffee, the supply of members' requirements, and the close alliance of the functions of the societies with the social and everyday life of their members were the best means to that end. The following paragraphs show briefly how the primary societies were formed and what their objects comprise.

The Union took every opportunity of impressing on growers the value of co-operative effort, and when a group of farmers in any one area (usually a chiefdom or sub-chiefdom) showed sufficient interest in the subject an open meeting was called, and after full discussions and explanations those who desired to proceed further with the formation of a society then elected a formation committee whose first duty was to discuss draft by-laws which the Union supplied. After agreement on the by-laws, and on their future line of action, the promoters applied for registration of the society, and after registration they held their first general meeting at which they enrolled new members, elected officers for the forthcoming year, engaged staff and applied to the Union for affiliation.

The main objects of each society are stated in a by-law which says they are to promote the economic interests of members in accordance with co-operative principles, and are particularly to carry out the following duties: To arrange the delivery of the produce of members for marketing through the Union and to provide services such as storage, transport, etc.; to do all things necessary for the care of the plantations of its members and for the prevention and eradication of pests and diseases of crops and animals; to receive and bulk the orders of members for seed, agricultural and building requirements, and to arrange their

purchase through the Union; to receive deposits of members and arrange for their repayment; to advance loans to members on security of their produce delivered to the society's store; and to encourage the spirit and practice of thrift, mutual help and self-help.

In most instances the new society received the assistance of the Union in building and equipping a store and office, and such assistance was mostly in the form of a loan of roofing, cement, weighers, etc., and many of the societies received free gifts from their members of building stones, sand, timber, etc.

After a society had completed its building it was able to commence receiving the produce of its members, and careful organization was then required to ensure accuracy in weighing, payments and issue of receipts. For these reasons the secretary and staff were chosen with great care and often a well-known elder of the community stood as guarantor for the secretary. The secretary is responsible, under the supervision of the managing committee, for bookkeeping, cash transactions and the general conduct of the work. Some secretaries handle as much as £25,000 a year. All cash payments are made before a witness and duplicates of cash books, receipts, etc., are sent to the Union for checking.

When the committee is elected at the annual meeting it is usual for the members to elect a committee-man to represent each village (*mtaa*) of the area covered by the society's operations, so as to ensure full representation. Committee meetings are usually held monthly.

The Union is composed of the societies affiliated to it, and a delegate (usually the chairman) from each society represents his society at general meetings, and has one vote. A deputy delegate (usually the vice-chairman) can also attend these meetings but has no vote, and is there so that the delegate can consult with him before giving a decision on any subject, and as a witness of the behaviour of the delegate when they report back to their society. From amongst the delegates are elected the managing committee of the Union, by secret ballot. Two committee men are elected from each of the three main divisions of Kilimanjaro (Hayi, Vunjo and Rombo) so as to ensure representation of the total area covered by all affiliated societies.

The Union has a staff comprising the manager, secretary and assistant, four supervising clerks and two store and tally clerks. It is the duty of the Union to supply its affiliated societies with market reports of crop prices and to advise them what to pay for certain crops and how and when to bulk them. The Union arranges collection of the produce from the society's godown and is also responsible for its sale and for remitting the sale proceeds to the society, after deducting a sale commission.

The objects of the Union, as stated in its by-laws, are to promote the economic interests of the affiliated societies in accordance with co-operative principles, and to arrange on their behalf for the sale in bulk of their agricultural and animal produce, and for the purchase in bulk of agricultural, building and other requirements, and to these ends to acquire land and provide such services, storage accommodation, transport and other services as may be necessary; to advance loans to affiliated societies; to encourage the development of co-operation among existing societies and to settle matters of common interest, and to assist the organization of further co-operative societies for affiliation to the Union; to exercise regular and careful supervision over the accounts of societies; to raise loans; to receive and invest deposits; and to promote other measures designed to encourage the spirit and practice of thrift, mutual help and self-help.

The funds of the Union are composed of a levy of one cent of a shilling per pound weight of parchment coffee handled, plus selling and purchasing commissions; whilst the funds of the affiliated societies are composed of a levy of one cent of a shilling per pound of coffee handled by them, plus the indivisible fractions of a cent of a shilling per unit of weight which cannot be distributed to the members, and also a portion of the selling commissions of the Union.

Steady progress has been made by the Union and its societies, and its activities have been extended. It has given assistance to visitors from all over East Africa who are interested in the movement and who want to start co-operative societies. It arranged for a small publicity film to be made which gave a history of the coffee industry of the Chagga and which was shown in London, New York and Nairobi to members of the coffee trade. New headquarter offices were opened in 1939, and the number of buildings erected by the affiliated societies on the mountain has been increased to thirty. At January, 1946, the membership of the Union comprised 27 affiliated societies with a combined membership of over 27,000, who own some 15,500 acres of bearing coffee. The

figures of produce and goods handled in the year which ended on 30th June, 1945, are:—

	Local value
Coffee, 3,932 tons (parchment) ..	£314,000
Other crops, 295 tons	£3,790
Onion seed, 3.2 tons	£2,042
Shade-dried hides and skins ..	£6,381
Agricultural implements and building materials	£4,472

An idea of the volume of work can be obtained when it is realized that an average load of produce weighed at primary societies is about 40 lb., so that with crops totalling over 4,000 tons there are nearly a quarter of a million separate weighments and produce receipts written out. Each coffee receipt entitles the owner to two or more cash payments (i.e. an advance payment on delivering the coffee, and interim and balance payments after sale), so that over half a million cash payments may be made in a season. Each payment is made before a witness, and accounts and records are checked by officials of the society, then by the Union, and finally by the auditors. The Union and its societies can be proud of the facts that cash shortages total a negligible sum, and that they have received no outside financial help nor hidden subsidy—they have stood on their own feet and worked out their own procedure. The chief benefit they give the members is that of service, which includes correct weighing and payments, bulk sale of produce and the supply of members' requirements. The management of the Union and the societies is entirely in the hands of Africans themselves.

Some of the difficulties which have been encountered are given here. As has been shown above, coffee was the *raison d'être* for the Chagga organizing themselves, and it is still the main activity of the K.N.C.U. Coffee had a most irregular market during the long period from 1929 to 1942, and the crops of the 1934–35 and 1935–36 seasons fetched record low prices. These poor prices caused discontent amongst growers everywhere which was reflected on Kilimanjaro by disturbances at the headquarters of four of the societies. Considerable Press notice was given to these disturbances and the K.N.C.U. received very bad publicity. The Tanganyika Government issued a memorandum on the subject (Sessional Paper No. 1 of 1937) which showed the active part played by a small number of agitators.

Meanwhile, a legal case (Tanganyika civil case No. 4, 1937) was before the courts for six years (1937–1942), in which the K.N.C.U. was originally cited as a co-defendant, to decide whether certain powers for sale of coffee which had been granted to the K.N.C.U. were legal. Exhaustive investigations were made into the working of the Union, and in a lengthy judgment of some 35,000 words, dealing with a number of issues, the judge stated he was satisfied that the Union is efficient and cheap, and trains members in business practices; further, that much supervisory work is done at a very low figure for which more substantial emoluments would be demanded under any other form of organization. Those interested in the subject of co-operation for Africans, and in constitutional law applied to African rule, are advised to read a copy of this judgment.

A happier event was when soon after the outbreak of war in 1939 the members of the K.N.C.U. contributed £1,000 for war purposes and to help the African soldiers. The Union sent a letter to Government with the gift saying: "It is the aim of the Chagga to do whatever they can to help Government to win the war so that we Africans can eventually live in peace and happiness under the guardianship of His Majesty and the British Flag." This was the subject of a leading article in the *Tanganyika Standard* for 26th January, 1940, part of which is quoted below:—

"The Kilimanjaro Native Co-operative Union is an organization of the utmost interest and importance. Probably the largest African Co-operative society in East Africa. . . . Its interests are not confined to the cultivation and marketing of coffee. Plans for rural reconstruction, such as communal cattle plots, hygienic butcheries, village mills, and other schemes have been put forward by the Union, and the local primary societies of the Union hold meetings in which with free speech and proper decorum the peasant expresses his opinions on crops, prices, land welfare, and other subjects relating closely to his welfare."

The history of the Chagga coffee industry on Kilimanjaro shows that during the past 20 years it has grown from producing 20 tons to 4,000 tons of coffee anually. At first the industry was organized by a native planters' association and then by the Co-operative Union. Voluntary co-operation, however, rarely embraces all producers, and it has proved necessary to control and stabilize the industry by means of a control board. The Native Coffee (Control and Marketing) Ordinance of 1937, provides for the establishment of native coffee boards in any area decided by Government. A board is a corporate body and has powers to give directions regarding sowing,

planting, cultivating, harvesting and preparation of native-grown coffee, and can also issue orders regarding grading, packing and marking. The Board can also make a compulsory marketing order.

The Moshi Native Coffee Board was formed in 1937 and until 1945 it delegated most of its powers to the K.N.C.U. Last year it was decided that the Board should itself carry out the main functions. The Board continues to employ the K.N.C.U. as its agent for organizing the collection of the coffee crop, payment of proceeds to growers, and the handling of the parchment coffee until it is ready for milling; but the Board now employs its own staff to carry out work which is calculated to promote more economic production and preparation.

The function of the Board is complementary to the work of the K.N.C.U. The Board is an instrument of Government and Government can invest it with any powers considered necessary for the benefit of the industry; whereas the K.N.C.U. is solely an instrument of the producers; it is a service-rendering organization and enables its members to speak with one voice.

CORRESPONDENCE

ARE GOATS A MENACE?

The Editor, East African Agricultural Journal.

DEAR SIR,

The eloquent writings from the pen of Mr. C. Maher on the menace of goats, published in recent numbers of your Journal, call for a reply. I happen to be one of the very few who have contributed actual experimental data basic to this problem. Mr. Maher in his enthusiasm and zeal to conserve the soil seems to me to overstate his case against the goat. Sound land-utilization can better be founded on well-planned schemes based on scientific facts rather than on popular theories which so frequently prove faulty when subjected to exact experiment. Preconceived ideas on dry-land farming and veldt burning are cases in point.

Preconceived ideas on the menace of the goat, held by myself and others at Mpwapwa, were much the same as those apparently still held by Mr. Maher, until we carried out definite experiments designed to obtain data to back up our views. The results, under conditions at Mpwapwa at any rate, were rather unexpected and very much in favour of the goat. Cattle were found to be far some effective in encouraging scrub growth and exposing the soil to the ravages of erosion.

While goats may be a menace under certain conditions of incorrect land use, cattle can be an even greater menace. It is significant that in the innumerable centres in Tanganyika where goats alone are kept, chiefly owing to the presence of tsetse flies, I did not see a single instance of serious damage done by these animals. In certain of the sleeping-sickness concentrations the numbers of goats run into many thousands on comparatively restricted areas.

It is true, too, that in Tanganyika in areas where cattle are kept, it is exceptional to find instances where the keeping of these animals, of course usually together with a percentage of goats, has not brought about obvious signs of damage to the land as a result of their grazing and trampling. I well remember, also, the rapid increase of scrub and the incidence of erosion in parts of the Mbulu Highlands, which was attributed even by the natives themselves, to the reduction in the numbers of goats through over-sales. In the Northern Transvaal very marked deterioration of the pasture and an increase in erosion has taken place in the last few decades. This deterioration has taken place in spite of an apparently smaller cattle population replacing an estimated greater game population, allowing for the differences in size of the respective animals. It is true other factors come into the picture, but the reduction in browsing does appear to be an important factor if not the most important.

Mr. Maher, I think, also minimizes the importance of goats as regards their potential economic value and their contribution to human nutrition. I do not have the exact figures available now, but in Nigeria a goat population of some 5,000,000 supports an export industry of skins of the annual value in the region of £500,000 and provides some 100,000,000 lb. of meat each year for human consumption, estimated mainly on the number of skins exported. This is no mean achievement for the goat! It is true that the East African goats do not achieve these results, but is there any real reason why they cannot if properly developed?

Finally I would plead for exact information based on research, and covering the widely varying conditions, before sweeping and dangerous generalizations are made public.

Yours faithfully,

R. R. STAPLES.

Department of Agriculture,
Salisbury, Southern Rhodesia.

6th March, 1946.

STORAGE—VENTILATION

By A. C. E. Callan, Inspector of Produce, Zanzibar

(*Received for publication on 5th March,* 1946)

Practically every commodity that is stored in bags requires proper ventilation. Through lack of air circulation most forms of produce are liable to become heated, especially if they are not reasonably free from moisture prior to storage. Good ventilation is, to a great extent, the means of maintaining quality with little or no deterioration.

The storage of rice in a ship illustrates the importance that is attached to ventilation. In this regard the first operation is to make the holds clean and dry. Pieces of strong and clean wood known as dunnage are then laid at the bottom of the hold crosswise and longwise. Vertical ventilators are placed at about five paces apart in three lines: down the centre and midway between the centre and each side. At the bottom of these ventilators and attached at right angles are strongly constructed ventilator boards. After every five tiers of bags are loaded, other ventilators are laid on top of the bags longitudinally, to connect with the vertical ones placed in position before the commencement of loading; and crosswise, to connect similarly the placed vertical ventilators in the next parallel line. As the top of each vertical ventilator is reached, others are added as required.

The whole system is thereby gradually linked up to circulate air throughout the cargo. On completion of loading it is possible to see the bottom of the hold down one of the ventilators when standing in the upper hatchway. Similar vertical ventilators reach to the inside of the ship's iron ventilators, which are permanent fixtures on the deck. The function of these deck ventilators is to allow the hot air to rise, and fresh air to descend, when they are trimmed according to the wind to "uptake" or "downtake" respectively. Rice cargoes which have been ventilated in this manner invariably produce a satisfactory outturn.

An advantage which storage in a godown has over storage in a ship is that every tier can be ventilated. This is effected by leaving a space of six inches in the rows of the cross tiers, the first of which lies on top of the longwise placed dunnage. The next tier need not have any spaces left but the bags should be placed longwise to maintain stability of the stack. With alternate crops and longwise tiers the stack should be both well ventilated and firm in structure. To obtain the best results from air channelling, however, it is essential to insert wooden ventilators in each row of the cross or spacing tiers. Ventilators ensure the passage of air by protecting the spaces from bag spread and sag, which may otherwise cause blockage. Godown ventilators can be made from scantling lengths of 3½ ft. by 7 in. by 1½ in. laid on edge parallel to each other and joined with at least four straps of wood, made from fairly strong pieces of about 6 in. lengths by 3 in. in width, nailed top and bottom of the scantlings at four equal distances. The strapped sides of the ventilators should be placed top and bottom in the spacing tier rows. Care should be exercised to see that no torn bags are put on the stack, as the spilled contents may block the air channels.

The initial outlay on ventilator equipment should amply repay the merchant who handles commodities that have to be stored for fairly long periods.

To attain the maximum benefit from ventilation, all godowns should be equipped with as many wall slits or windows as possible, and these should, if possible, be above the top of the stack of produce, though if the stack is kept clear of the walls, as it should be, then the question of stacking above the vent slits or windows does not arise, as air will enter and circulate freely. Open expanded metal on top of the walls under the eaves is ideal for ventilation.

Every merchant who stores commodities should make himself familiar with ventilation problems in order to prevent possible heating and deterioration.

If a man will begin with certainties he shall end in doubts, but if he will be content to begin with doubts he shall end in certainties.

Francis Bacon.

To be happy in this world it is necessary to have a definite objective and an emotional interest.

W. Langdon-Brown in *Thus we are men.*

THE CONSTITUENTS OF THE SOLIDS-NOT-FAT OF KENYA MILK

By H. S. Purchase and A. A. Reverberi, Veterinary Research Laboratory, Kabete, Kenya

Recent routine analyses of milk samples have revealed that often the S.N.F. were below that required by Kenya law, viz. 8.5 per cent. As these samples were of unadulterated milk it was decided to carry out complete analyses to elucidate what constituent of Kenya milk was the cause of low S.N.F. Sixty-five samples were investigated from eighteen herds representing six different breeds. The figures given for protein were obtained by multiplying the amount of nitrogen found by 6.38. The lactose was estimated by subtracting the amount of protein and ash from the S.N.F. With the exception of samples A and K, which were fresh, the milk was preserved by the addition of 1 per cent by volume of a solution containing 10 per cent pot. bichromate.

As published work had indicated that the quality of the milk from a cow could vary with the grazing conditions, the samples examined are divided into two groups:—

Table I shows results obtained from milk samples taken during the "dry season" when grazing was parched and scarce and when concentrates were being fed heavily. Only eight samples had 8.5 per cent S.N.F. or over and therefore came within the limits defined by law. If Smith's (1905) figures are taken as reasonable, then it will be seen that only one of the 35 samples is within the range he gives for lactose content. The protein percentages satisfies Smith's average in eight samples, and there are only six figures below 3.2 per cent. It will be seen, therefore, that the low S.N.F. *are in the main* due to the low lactose content.

Table II is a summary of the analyses of milk taken during the "rainy season", that is, taken after the cows had grazed for at least two weeks, but in most cases for a longer period, on ample, good, lush grass. A supplement of concentrates was also being fed. The supplements commonly used in Kenya during these observations were cotton seed, cotton-seed cake, simsim cake, copra cake and bran.

Discussion

It is evident from the above tables that the breed of cow influences the S.N.F. content in Kenya. Milk from the native Guernsey and Shorthorn herds examined was superior in this respect to that from Ayrshire and Friesian cows.

French (1934) has recorded the monthly average of S.N.F. of Government-owned grade Ayrshire and Friesians in Tanganyika for the years 1932–34 and found the S.N.F. to be satisfactory except for October, 1932, and June, 1934. In the Tanganyika Veterinary Department's report for 1937 French gives the S.N.F. figures covering the eight years 1930–37 of grade Friesian milk, and in every recorded month some samples were found to fall below the legal standard required. In May, 1931, the best month, only 4.3 per cent of samples were below the 8.5 per cent S.N.F. standard, and in October and November, 1937, the worst period, 95.8 per cent of the samples were below.

In conclusion French (1937) stated "these figures suggest that the increase in the number of milk samples deficient in non-fatty solids is not due to hereditary factors transmitted by the last three bulls, though they do not eliminate the possibility that one of the original bulls introduced this character; in fact this seems the more likely explanation, because of the large number of half-grade cows which have consistently given deficient milk. That this tendency has been transmitted from the original native cows is a possibility, but in view of the normal figures found by the Government Analyst for native milk sold in the township this seems unlikely because native milk is not often below the 8.5 per cent limit."

Lesser (1932) studied a herd of British Friesians in Hampshire and found that the low S.N.F. was "associated with an abnormal small quantity of lactose in the milk accompanied by a high chloride content". Although this herd was fed on a high level of nutrition this deficiency continued throughout the winter but when the cows were turned out to graze the lactose content of the milk increased and the S.N.F. returned to normal.

Baker and Cranfield (1933) studied the S.N.F. of bulked samples in Derbyshire, Cheshire, Staffordshire and Leicestershire, and found a definite correlation between the annual rainfall and S.N.F. Dry years produced a higher proportion of deficient samples than years with normal rainfall.

Rowland (1944) associated the low S.N.F. with "low plane of nutrition" during the winter and quotes the work of Riddett (1941) and his

TABLE I—ANALYSES OF MILK DURING DRY PERIOD

Breed	Farm	Specific gravity	Total solids	Butter-fat	Solid not fat	Protein	Lactose	Ash	Remarks
Friesland ..	A	1·0311	12·10	4·30	7·80	3·16	3·90	0·74	Evening milk, bottled and obtained from delivery van.
		1·0311	12·42	4·40	8·02	3·34	3·94	0·74	Evening milk properly bulked.
		1·0312	11·64	3·40	8·24	3·09	4·45	0·70	Morning milk, bottled and obtained from delivery van.
		1·0318	11·95	3·50	8·45	3·15	4·33	0·74	Morning milk properly bulked.
Friesland ..	B	1·0291	11·67	3·6	8·07	3·25	4·07	0·75	Bulked sample.
Friesland ..	C	1·0309	12·39	4·3	8·09	3·40	4·00	0·69	Bulked sample.
Friesland ..	D	1·0310	11·34	3·5	7·84	3·24	3·83	0·77	Evening milk bulked pure-bred cow.
		1·0315	11·51	3·8	7·71	4·15	2·82	0·74	Morning milk bulked pure-bred cow.
		1·0325	13·06	4·5	8·56	4·04	3·78	0·74	Bulked sample high-grade cows.
		1·0310	12·57	4·4	8·17	3·41	4·03	0·73	Bulked sample high-grade cows.
Friesland ..	E	1·0312	11·24	3·4	7·84	3·24	3·85	0·75	Evening milk bulked high-grade cows.
		1·0320	11·83	3·6	8·23	3·30	4·19	0·74	Morning milk bulked high-grade cows.
		1·0312	11·72	3·6	8·12	3·34	4·03	0·75	Bulked sample pure-bred cows.
		1·0296	11·47	3·4	8·07	3·23	4·09	0·75	Bulked sample bure-bred cows.
Ayrshire ..	F	1·0330	12·85	4·2	8·65	3·65	4·25	0·75	Bulked sample.
Ayrshire ..	G	1·0380	12·52	3·6	8·92	3·40	4·73	0·79	Bulked sample.
Ayrshire ..	H	1·0320	12·48	3·9	8·58	3·56	4·28	0·74	Bulked sample.
Ayrshire ..	I	1·0299	11·16	3·5	7·66	3·33	3·63	0·70	Bulked sample morning milk.
Ayrshire ..	J	1·0301	13·82	5·7	8·12	3·40	3·97	0·75	Bulked sample pure-bred cows.
Ayrshire ..	K	1·0300	12·57	4·1	8·47	3·56	4·20	0·71	Morning bulked sample.
		1·0300	11·97	3·7	8·27	3·66	3·91	0·70	Evening bulked sample.
Ayrshire ..	L	1·0269	12·35	4·6	7·75	2·84	4·17	0·74	Evening bulked sample grade cows.
		1·0290	11·28	3·7	7·58	2·96	3·88	0·74	Morning bulked sample grade cows.
Shorthorn ..	M	1·0315	13·19	4·5	8·69	3·52	4·42	0·75	Morning bulked sample.
		1·0319	13·21	4·8	8·41	3·64	4·02	0·75	Evening bulked sample.
Guernsey ..	N	1·0300	13·55	5·0	8·55	3·50	4·32	0·73	Morning bulked sample.
		1·0301	14·00	5·8	8·20	4·04	3·37	0·79	Evening bulked sample.
Red Poll ..	O	1·0318	13·00	4·8	8·20	3·29	4·15	0·76	Morning bulked sample.
		1·0315	12·46	4·1	8·36	3·28	4·34	0·74	Evening bulked sample.
Mixed grade	P	1·0381	11·57	3·5	8·07	3·27	4·06	0·74	Morning bulked sample.
		1·0340	11·35	3·2	8·15	3·30	4·10	0·75	Evening bulked sample.
Native ..	Q	1·0310	15·33	6·4	8·93	3·80	4·34	0·79	Masai cows.
		1·0312	15·17	6·2	8·97	4·06	4·12	0·79	Boran cows.
Native grade	R	1·0340	13·22	4·4	8·82	3·78	4·28	0·76	These samples are from sea-level, Mombasa.
		1·0320	13·05	4·6	8·45	3·50	4·16	0·79	Ditto.
Smiths (1905) average..	—	—	12·66	3·72	8·94	3·59	4·62	0·73	"Average of many thousands analyses."

TABLE II—ANALYSES OF BULKED MILK FROM COWS ON LUSH GRAZING

Breed	Farm	Specific gravity	Total solids	Butter-fat	Solid not fat	Protein	Lactose	Ash	Remarks
Friesland ..	A	1·0285 1·0296	11·13 11·02	3·7 3·1	7·43 7·92	3·02 3·04	3·72 4·18	0·69 0·70	a.m. milk. p.m. milk.
Friesland ..	B	1·0310 1·0299	11·27 11·97	3·8 4·4	7·47 7·57	3·03 3·39	3·70 3·40	0·74 0·78	a.m. milk. p.m. milk.
Friesland ..	C	1·0325 1·0326	11·57 12·92	3·4 4·4	8·17 8·52	3·45 3·75	3·93 3·98	0·79 0·79	a.m. milk. p.m. milk.
Friesland ..	D	1·0320 1·0310	11·88 12·21	3·5 4·0	8·38 8·21	3·69 3·58	3·99 3·90	0·70 0·73	a.m. milk. p.m. milk.
Friesland ..	E	1·0325 1·0320 1·0311 1·0315	12·21 12·22 11·25 11·72	4·4 4·5 3·7 3·9	7·81 7·72 7·55 7·82	4·05 3·97 3·42 3·56	3·07 3·06 3·44 3·57	0·69 0·69 0·69 0·69	a.m. milk, high-grade. p.m. milk, high-grade. a.m. milk, pure-bred. p.m. milk, pure-bred.
Ayrshire ..	F	1·0330 1·0320	13·21 13·47	4·8 5·1	8·41 8·37	4·03 3·50	3·57 4·02	0·81 0·85	a.m. milk. p.m. milk.
Ayrshire ..	G	1·0322 1·0310	12·22 12·62	4·1 4·7	8·12 7·92	3·50 3·39	3·83 3·74	0·79 0·79	a.m. milk. p.m. milk.
Ayrshire ..	H	1·0302 1·0281	12·29 13·25	4·2 5·4	8·09 7·85	3·22 3·32	4·08 3·79	0·79 0·74	a.m. milk. p.m. milk.
Ayrshire ..	J	1·0321 1·0315	12·55 13·29	4·5 5·2	8·05 8·09	3·95 3·66	3·35 3·66	0·75 0·77	a.m. milk. p.m. milk.
Ayrshire ..	K	1·0315 1·0306	11·95 12·77	4·2 5·1	7·75 7·67	3·38 3·46	3·58 3·42	0·79 0·79	a.m. milk. p.m. milk.
Ayrshire ..	L	1·0316 1·0300	11·85 12·70	3·6 4·7	8·25 8·00	3·11 3·29	4·44 4·01	0·70 0·70	a.m. milk. p.m. milk.
Shorthorn..	M	1·0330 1·0340	13·40 13·13	4·8 4·5	8·60 8·63	4·02 3·92	3·79 3·92	0·79 0·79	a.m. milk. p.m. milk.
Native ..	Q	1·0320 1·0320 1·0310 1·0312	15·20 15·16 13·75 13·77	6·5 6·5 6·0 6·1	8·70 8·66 7·75 7·67	3·87 3·92 3·29 3·28	4·03 3·93 3·68 3·60	0·80 0·81 0·78 0·79	a.m. Masai cows. p.m. Masai cows. a.m. Boran cows. p.m. Boran cows.

collaborators who found that in New Zealand underfed cows produced milk deficient in S.N.F.

Although small variations have been recorded by Bartlett (1934) in the S.N.F. content associated with the age of the cow this factor would not play any important part when bulked samples are considered.

The investigations reported here were carried out from November, 1944, to February, 1945, at a time when the short rains, which were poor, were tailing off and the grazing was rapidly ageing, and again during the April–June rains when there was plenty of green grass.

CONCLUSION

1. Samples of genuine unadulterated cows' milk investigated in Kenya often showed a low non-fatty solids fraction.

2. This deficiency is associated with low lactose content and was more prevalent in Friesian and Ayrshire breeds.

3. The low S.N.F. content of milk occurs throughout the year, both in the dry season when concentrates are fed extensively and in the rainy period when there is plenty of green lush grazing.

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NOTES ON ANIMAL DISEASES

Compiled by the Department of Veterinary Services, Kenya

I—REDWATER AND ANAPLASMOSIS*

REDWATER

Redwater is a tick-borne disease generally distributed throughout East Africa. On farms where dipping is not practised, every calf contracts the disease on the average 15 days from birth. Where dipping has reduced the tick population to a low figure, however, cattle may escape infection during calfhood, and severe losses may occur if they are moved to a farm where infected ticks still occur.

Cause.—Several species of related protozoon parasites which produce redwater in cattle are known from different parts of the world, but only one, *Babesia bigemina*, occurs in Kenya. Although there may be some difference in virulence among different strains, there is no evidence to sugest that more than one immunologic strain occurs in Africa.

The parasites may be seen in blood smears. They invade and multiply in the red cells. Attacked cells are broken down in the body, and the red pigment of the cells (hæmoglobin) is liberated. Part of this pigment is converted by the liver into bile pigment, excess of which in the tissues causes jaundice, and part is excreted by the kidneys, giving rise to the characteristic symptom, hæmoglobinuria, from which the disease takes its name "redwater".

Incubation period.—Following natural infection from the bites of ticks, the incubation period is 8 to 17 days. After the inoculation of blood, as during immunization with the so-called "vaccine", the reaction begins in 5 to 15 days, usually about the tenth day.

Symptoms.—The first sign of infection is usually a rise in temperature. The temperature may go to 105° F. or higher. If the animal is untreated the temperature remains elevated for several days, after which it returns slowly to normal or, in fatal cases, may fall suddenly to below normal a short time before death.

In the early stages there is dullness and a staring coat, and in severe cases there is marked disinclination to feed. During the later stages œdema of the lungs may cause distressed respiration. Nervous symptoms are not uncommon, being restricted usually to an unsteady gait; but occasionally signs of frenzy appear, the animal having uneasy, staring eyes and being liable to charge anyone approaching it. Depending on the rapidity of destruction of the blood cells, a reddish coloration, varying from pale red to deep claret, of the urine may be observed early in the course of the disease, or may be postponed until the fifth or sixth day of the temperature reaction. Examination of the eyes and the visible mucous membranes may reveal the existence of jaundice.

Post-mortem appearances.—The blood appears thin and watery, the serum usually being tinged red. The loose tissue beneath the skin, the outer coats of the stomach and intestines and the whites of the eyes are often tinted a golden-yellow. The muscles may be pale and flabby.

In acute cases there is often œdema of the lungs and froth in the air passages and at the nostrils. The interlobular tissues of the lungs are then infiltrated with a yellowish fluid, causing the surface of these organs to appear to possess yellow veins. The heart-sac may contain an excess of fluid, often yellowish in colour. The heart itself usually shows hæmorrhages on its surface and in the lining membranes of the cavities. There may be a yellowish gelatinous infiltration around the base of the heart.

The spleen is always considerably enlarged, its pulp being soft and dark in colour. The liver is enlarged and congested; usually it has a bright orange colour on section. The gall-bladder is distended and the bile thick in consistency. The capsules of the kidneys may be infiltrated with a gelatinous exudate. The kidneys, in acute cases, are congested.

The mucous membrane of the fourth stomach is claret-coloured and shows hæmorrhages on its surface. Stripes and patches of congestion and hæmorrhagic spots may be present in the intestines. The urine in the bladder is port-wine or dark-brown in colour.

Differential diagnosis.—Redwater may be confused with several diseases, only three of which will be discussed here.

Cases occurring in adult cattle, not under close observation, may from a report of sudden death, and from the large size of the spleen seen at post-mortem examination, be confused

* A revision of the article on this subject which appeared in this Journal in January, 1939.—*Ed.*

with anthrax. The appearance of the blood is usually sufficient to distinguish anthrax from redwater, for in the former disease it is very dark, often black in colour, and tarry in consistence.

The stiff gait observed in redwater is not infrequently mistaken for a symptom of heartwater. Redwater cases showing stiffness, however, have almost always reached the stage at which the urine is characteristically coloured.

Finally, the appearance of the urine in redwater is due to pigment only. This appearance must not be confused with the presence of actual blood and blood clots in the urine, a symptom characteristic of enzootic hæmaturia. This later is a chronic disease, usually found in cows and work oxen, which appears to be restricted to certain parts of the Limuru, Kericho, and Hoey's Bridge districts, and is almost certainly a nutritional disorder.

When submitting smears for confirmation of diagnosis, smears taken from the ear vein should always be sent. Blood is always present in the spleen, but it is often difficult to detect parasites in a spleen smear.

Transmission.—The most important vecting tick in Kenya is *Boophilus annulatus* var. *decoloratus*, the common blue tick. This tick is a one-host tick; that is to say, it spends its whole life on one animal, not dropping to the ground to moult between the larval and nymphal or between the nymphal and adult stages. The engorged females drop to lay their eggs and the larvae that hatch obtain a host in the usual way. For such a tick to transmit a parasite from one host to another it is of course obvious that the infection must pass through the egg. Infection has also been shown to pass through the egg in the case of a two-host tick, *Rhipicephalus bursa*. With *Boophilus annulatus* it has been proved that, once a batch of ticks is infected, several generations may be passed on insusceptible animals without the infection being lost, and with *Rhipicephalus bursa* that the feeding of the larval-nymphal stage of infected ticks on a horse failed to render them, after moulting to adults, non-infective for susceptible catle.

Less effective transmitters are *Rhipicephalus appendiculatus*, the brown tick, and *R. evertsi*, in neither of which has it been possible to demonstrate the transmission of infection through the egg.

While definite information on the point appears to be lacking, it is probable that, as in the case of tick fever in the dog and East Coast fever in cattle, a tick is not able to infect cattle with redwater until it has been feeding for three to four days.

Treatment.—Several drugs are available which have a specific lethal action on the parasite. The most valuable of these are trypanblue and pirevan or piroparv (acaprin).

Trypanblue for the treatment of redwater is issued by the Laboratory at Kabete in tubes containing one maximum dose. The contents of the tube are dissolved in about 200 c.c. of clean boiling water and then the solution is allowed to cool. When quite cold the solution is filtered through blotting paper or filter paper. It is essential that the solution be allowed to cool properly, or some of the drug may come out of solution after filtration, and in the solid state it is very irritating to the tissues.

An average subcutaneous dose of the solution for an adult animal is 120 to 160 c.c. The solution may be inoculated either subcutaneously or intravenously. Unless the operator has had considerable experience of the intravenous method, the former is recommended. For preference the solution should be warmed to blood heat before inoculation, divided and inoculated at four different sites; for example, one in front of and one behind each shoulder. Needless to remark, the syringe and needles should be sterilized by boiling before use and the sites of inoculation cleansed with a solution of some disinfectant.

Should a swelling develop at any of the sites it should not be opened unless it points. Swellings often form that are not the result of bacterial infection, and if fomented daily with warm water they will disappear without bursting.

The frequency with which the use of trypanblue is followed by the appearance of abscesses is a distinct disadvantage from the farmer's viewpoint and for this reason, pirevan or proparv is popular with stockowners. These drugs are the British equivalents of the Bayer drug, acaprin. They are not issued by the laboratory, but may be obtained from the retail chemists in Nairobi and are sold as a 5 per cent solution ready for use. The dose is 1 c.c. per 120 lb. bodyweight, and it is advisable to adjust the dose accurately. This drug is undoubtedly less troublesome to use than trypanblue and, from reports received, it appears to be very effective.

Another drug of some value is phenamidine, which is obtainable from chemists as a 5 per cent solution.

Preventive measures.—The preventive measures against redwater are dipping and protective inoculation. As dipping is used similarly against anaplasmosis and inoculation against the two diseases is usually combined, discussion is postponed until the latter disease has been described.

ANAPLASMOSIS (TRUE GALLSICKNESS)

This disease occurs on all farms where redwater is present. Where dipping is not carried out, calves go through anaplasmosis during the third month of life. Imported European cattle, and a percentage of cattle from farms where dipping from birth is practised, are highly susceptible.

Cause.—Anaplasmosis is due to a microscopic parasite which invades the red blood cells. In blood smears the parasites are seen as a black dot occurring on the margin or in the centre of the cells. In the former case the parasite is *Anaplasma marginale* and in the latter *A. centrale.* As the parasites are very small and show no characteristic internal structures, care should always be taken that good clean blood smears are submitted for diagnosis. It is not always possible to give a definite diagnosis from spleen smears.

It is the exception to find *A. centrale* in cases infected naturally. A strain of this parasite, which produces a milder form of the disease, is used in the immunization procedure.

In calves reared under ranching methods anaplasmosis is a very mild disease. Calves that are hand reared are somewhat more susceptible, although in these also, provided that they are properly fed and are free from complicating diseases such as paratyphoid, the reaction should be so slight as to pass unnoticed.

The term "gallsickness" is used loosely to cover a variety of conditions, mainly digestive disorders.

Symptoms.—The symptoms in many respects resemble those of redwater, except that red urine is not passed. The first indication of infection is a rise in temperature, usually gradual, but sometimes rather sudden. The animal appears dull, there is a staring coat and disinclination to feed. Constipation is usually marked, but in the later stages diarrhoea may supervene. As in redwater, oedema of the lungs may occur.

During the acute stage the skin and visible mucous membrane may have a yellowish colour. When this stage has passed it is usual to find marked anaemia, manifest in a paleness of the eyes, lips, gums, and of the vulva in female stock. The tongue is usually notably white.

Death may occur in the acute stage, but some of the animals that survive this die later of anaemia and cachexia.

Post-mortem appearances.—The characteristic appearance is that of a jaundiced condition of the tissues. In protracted cases the carcass is emaciated, the flesh pale and the blood pale and watery.

The lungs are sometimes œdematous, a frothy fluid exuding from the surface when cut. Froth may be present in the wind-pipe. The chest cavity and heart-sac may contain an excess of yellowish fluid. The heart may show patches of small hæmorrhages on the surface and either patches or stripes of hæmorrhages on the linings of the cavities.

The liver is enlarged and usually yellowish-brown in colour. The gall-bladder is distended and thickened yellow or orange bile. The kidneys may be congested. Usually they are stained yellow. The urine is pale.

The spleen is often enlarged and the pulp soft in consistence. In animals that die several days after the acute symptoms have subsided this organ may appear thin and shrunken. Lesions in the fourth stomach and intestines vary in intensity. The fourth stomach may show hæmorrhagic points and the intestines contain a quantity of mucous; in some instances acute inflammation of these organs is present.

The lymphatic glands are usually enlarged and flabby.

In chronic cases and in calves diagnosis may be impossible from an examination of the carcass, which may reveal little except cachexia and a pale watery condition of the tissues in general

Transmission.—As with redwater, the most important East African transmitting tick is *Boophilus annulatus* var. *decoloratus*. Members of many other tick genera (*Amblyomma, Hyalomma, Dermacentor, Ixodes and Rhipicephalus*) can transmit anaplasmosis, but hereditary transmission has only been proved in some varieties of *Boophilus annulatus, Rhipicephalus simus,* and a tick that does not occur in East Africa, *Ixodes ricinus.* It is very doubtful if transmission through the egg ever takes place in *Rhipicephalus bursa* and *R. appendiculatus.*

In America outbreaks of anaplasmosis have been attributed to direct transfer of blood from animal to animal during the operation of dehorning and while bleeding cattle for contagious abortion agglutination tests. Biting flies of the genus *Tabanus* have also been blamed for mechanical transmission.

Treatment.—Unfortunately, no specific drugs of efficacy comparable to that of trypanblue in redwater are available for the treatment of anaplasmosis. A considerable amount of work is being done on this subject by the United States of America Bureau of Animal Husbandry scientific staff. Owing to the fact that the disease is restricted to certain States, ample supplies of highly suscepible adult cattle are available for experiment in America; whereas in Kenya cattle have to be reared in stables under tick-free conditions until they are at least a couple of years old before they are really suitable for testing the effects of various drugs.

Symptomatic treatment and careful nursing are of considerable value. The animal should be placed in a comfortable, dry stable and given green fodder and good hay. Sloppy mashes with the addition of molasses help to provoke thirst and to prevent constipation. Any tendency to constipation should be corrected by a dose of linseed oil or salts with 25 to 35 grains of calomel. If the animal appears depressed or refuses food, stimulants such as ammonium carbonate and nux vomica should be given two or three times daily.

Tonics containing arsenic (such as stovarsol, acetylarsol, sodium cacodylate) are considered by some workers to be of value during convalescence; but neither such drugs, sulphanilamide, acaprin nor stilbamidine have any specific lethal action on the parasite. Preliminary reports suggest two methods of treatment as worthy of further investigation. The first consists in the administration of large quantities of blood from a healthy ox intravenously. This method, which really amounts to a blood transfusion, is not to be recommended for routine use in Kenya, since there is a risk of transmitting redwater from the donor to the sick beast and since large doses of blood given intravenously to cattle are liable to produce death from shock. The other method is to fill the stomach daily with water until it is "comfortably distended". This is done by the use of a stomach tube inserted via the mouth into the gullet. Such a treatment is well worth trial in valuable animals.

Dipping as a preventive measure against Redwater and Anaplasmosis.—The obvious method of preventing the occurrence of redwater and anaplasmosis is to eliminate the transmitting ticks by dipping. By reducing the number of ticks, other tick-borne diseases such as east coast fever and heartwater are also controlled, and there is little doubt that a cattle dip is one of the first essentials for a farm where stock are to be kept.

One-host ticks, such as *Boophilus annulatus* var. *decoloratus*, which remain attached to the one animal for a period of three to four weeks, are the easiest to control by dipping and may be destroyed by dipping at intervals of 3, 5, 7 or 14 days. To prevent brown ticks from dropping engorged from recovered redwater gallsickness cattle, dipping at intervals of three or five days should be combined with hand dressing. The larval and nymphal stage of *R. evertsi*, the red-legged tick, remains on the host for ten days, hence dipping within this period will effect its destruction.

Larval blue ticks can live for about eight months without a host. If a farm is well stocked and dipping regularly carried out in a dip kept up to proper strength, the majority of blue ticks on the grazing should be killed in about eight months.

Dipping, even at intervals of seven or 14 days, by killing off the majority of blue ticks soon results in a percentage of cattle reaching maturity without having passed through an attack of redwater and anaplasmosis. Short-interval dipping combined with thorough hand-dressing results in this stage being reached earlier. Mortality from these diseases in adult cattle may now occur. It is the practice on many farms to leave the calves undipped until several months old in the hope that they will become infected and lose their susceptibility. This practice is most unsatisfactory, for it prolongs the low-tick-infestation period indefinitely. There is little point in taking vigorous steps to eradicate ticks on adult cattle and at the same time breeding them on the calves. The eventual goal is presumably the complete eradication of ticks from the farm, and every step should be taken to attain this end as soon as possible. During the transition period calves may be given a dose of redwater-anaplasmosis blood which will ensure, with much more certainty than if infection had been left to ticks, that they become infected with these diseases, and in a reasonably short time the danger period will be over.

Immunity in Redwater and Anaplasmosis.—Animals that have recovered from redwater and anaplasmosis infection continue to harbour the parasites in their blood for varying periods of time. In redwater, infection has been known to persist for from twelve months to twelve years after removal from any possible source of reinfection. In such animals parasites cannot be found on microscopical examination of the blood; but although to all appearances they are in perfect health, their blood, on inoculation to susceptible cattle, will transmit the diseases.

Reinoculation of recovered cattle with redwater and anaplasmosis will not cause any noticeable reaction. However, if a large dose of multiplying redwater parasites is given, parasites may be detectable in the blood again for a few days. Therefore although they are immune the condition of recovered redwater-anaplasmosis animals differs from that of animals that have recovered from a disease like rinderpest, from which the virus cannot be recovered, and the name "premunity" is now used for the former condition. Animals in the premunized state may show relapses when attacked by another disease, such as east coast fever, or when exposed to such detrimental influences as long railway journeys or marked changes in altitude.

Inoculation of cattle against Redwater and Anaplasmosis.—The system of preventive inoculation against redwater consists in inoculating blood from a recovered redwater animal so that a reaction to the disease occurs while the inoculated animal is under close observation. Actually inoculation of blood containing the parasites of redwater usually results in a milder reaction than when infection is contracted from the bite of a tick. By taking the temperature each morning and evening throughout the time that the reaction is to be expected the first sign of infection is detected. If the temperature goes above 104° F., or the animal refuses to eat, a proper dose of trypanblue or acaprin should be given.

Protection against anaplasmosis is effected by two inoculations. The first inoculation is with the blood of an animal harbouring *A. centrale*, which produces a milder reaction than the wild *A. marginale* and gives a certain amount of protection against the latter parasite. The second inoculation is given when the first reaction is over and the animal's health has returned to normal.

Cattle undergoing inoculation must be kept under tick-free conditions, at least until the reactions to redwater and *A. centrale* are over. The ground around the stable in which they are kept should be cleared of grass for a distance of ten feet and should be kept clean. The cattle should be exercised on a piece of hard ground free from grass. Fodder and other foodstuffs should be free from ticks.

When inoculating imported cattle the usual procedure is first to inoculate pure *A. centrale* blood. The period between the inoculation of the blood and the first signs of the reaction varies from 30 to 50 days, and the animal has thus about a month to become acclimatized to East African conditions. The duration of the reaction is from four to 40 days. Slides should be submitted to a veterinary officer or to the laboratory during the time that the reaction is to be expected, every other day, until a confirmation of the presence of the parasite is received. Slides should then be sent at weekly intervals so that the state of the animal's blood can be followed and the time when it will be considered safe to inoculate the second vaccine can be judged. If necessary, symptomatic treatment should be given.

When the animal has recovered from the *A. centrale* reaction, blood containing redwater and *A. marginale* is inoculated. The reaction to redwater begins from five to 15 days after inoculation. Slides should be submitted daily during this period until a diagnosis of redwater is received. If necessary—that is, if the temperature rises above 104° F. or the animal refuses food—treatment should be given. The reaction to *A. marginale* occurs 30 to 50 days after the blood has been inoculated, and slides are taken and treatment given, if necessary, as in the case of the *A. centrale* reaction. In all cases when submitting smears the date of inoculation and type of vaccine, together with the animal's temperature, should be stated on the slide folder. In addition to slides at the stated periods, slides should be sent for examination at any time that the animal's temperature shows an abnormal rise.

When inoculating cattle purchased locally it is advisable to inoculate redwater along with the first *A. centrale* vaccine. The question of acclimatization does not arise, and the sooner the reaction to redwater is over the better, as danger of a chance reaction from infection by a stray tick is reduced. The reaction to redwater is then awaited at the usual time, but after the first inoculation. Otherwise the procedure is the same.

Generally speaking the inoculation of in-calf cows and heifers is not recommended. During the early months of pregnancy the procedure is usually free from risk of abortion, but the advice of a veterinary officer should be obtained when such inoculations are contemplated.

Young calves, if properly fed and in good health, may be inoculated with redwater and *A. marginale* and left without further special attention. The reactions should be so mild as to pass unnoticed. Our general experience in Kenya, however, is that except for ranched calves, it is better to give a mixed redwater and *A. centrale* injection. On many large estates it is customary now to inoculate monthly or two-monthly batches of calves between six to 12 weeks of age with such blood. Reactions are hardly noticed and a serviceable immunity appears to be developed.

It should be remembered that the vaccine is not a vaccine in the true sense of the term. It will not prevent the condition known as anaplasmosis in calves. For this condition to occur in calves, the vitality of the calf must be lowered by some other factor, and this factor is just as likely to provoke a severe reaction to the vaccine as during the course of infection naturally contracted from ticks. To control anaplasmosis in young calves, attention should be given to feeding, housing, and to the elimination of paratyphoid, bacillary necrosis and other calf diseases.

REVIEW

A Notebook of Tropical Agriculture, by R. Cecil Wood, published by the Imperial College of Tropical Agriculture, Trinidad, B.W.I.; London Office, Grand Buildings, Trafalgar Square, London, W.C. 2, 1945, Price Sh. 10/6.

This third edition of Wood's Notebook is really a reprint, as there are no major changes, although it includes a few minor alterations. It is a very useful collection of odds and ends of information which would otherwise have to be hunted for in textbooks and journals. Like all handbooks it has to be used for some time before it can be appreciated, but when it has been kept within easy reach for a few months it proves its worth.

Notes on crops include seed rates, planting distances, number of seeds per lb., and the ranges of yields per acre. The live stock, feeding, and dairying sections contain much useful information for the planter or agricultural officer, and the notes on statistics give Fisher's tables of t and z. The tables of weights and measures have a strong tropical bias in giving a list of those peculiar weights and measures which are used locally in the Colonial Empire, India and Egypt. Data are also given on surveying, buildings and roads, agricultural machinery, manures, labour, and soils, and one of the sections gives recipes for insecticides, fungicides, dips, and book poison.

It may seem strange to praise the blank pages in a book, but a most useful technique has been adopted in having every alternate page blank, so that one's own notes can be added and referred to in the index. Facts and recipes which crop up in the course of reading can be put alongside other notes on the same subject, and data of local accuracy can be added to the figures for crops yields, etc., which have of necessity been generalized.

Criticism can be levelled at the publishers' method of distribution of the book, since, officially "it can be obtained on application to the Editor, Imperial College of Tropical Agriculture, Trinidad". This is inconvenient for anyone who deals with a bookseller in England, and few will take the trouble to find out the easiest way of sending money to the West Indies. For that reason, the London address of the College is given above, in the hope that copies can be obtained from that office.

While it is to be presumed that the price quoted includes postage, this has not been stated definitely.

D. W. D.

DISCUSSION ON A PAPER ON "PRINCIPLES GOVERNING WATER-FINDING"

(At the meeting of the East African Association of Engineers on 6th November, 1945)

MR. J. POLLOK (MEMBER):

I would like to congratulate Dr. Parsons on his paper. It was a pleasure to read it.

The report on the Nairobi Municipal water supply made by Mr. F. E. Kanthack emphasises the important part which the geologist exercises on major water supply schemes. Their position is perhaps not so vital on smaller schemes.

Mr. H. F. Mariott said at a recent meeting of the Institute of Civil Engineers when discussing a paper on rural water supplies: "Speaking as a geologist he would not trust a geologist or any technical man to tell him where to put a well".

A problem which worries the Water Engineer is the question of "seepage" from storage reservoirs, and if it is not "seepage" then it is "silting up". Dr. Parsons mentions the disappearance of a river through a geological fault in its bed. If the scouring out of a river bed could cause this trouble, is it not equally likely that the depositing of silt in a reservoir will help to seal up any surface porosity of the original ground?

It is well known that concrete dams which show quite considerable leakage when first brought into use gradually seal up and become watertight. Large storage reservoirs have been built in the Western Ghats of India and the geological formation is much similar to that of a great part of Kenya.

Other problems which worry the Water Engineer in this country are those of "run-off" and "flood-discharge".

With regard to run-off it appears to be the general practice in tropical and semi-tropical countries to ignore any rainfall less than one inch intensity during the recognized dry season and to base the percentage of run-off on the rainfall during the wet season. In the United States of America it appears to be the practice to take only the annual rainfall over twenty inches as run-off, but in most of the U.S.A. the rainfall is distributed more evenly than in Kenya.

I am glad to see that Dr. Parsons favours the construction of small dams here. One of the troubles met with by the water engineer is the quantity of flood-water to be by-passed. If an earth dam is the only practicable type which can be constructed, it may be found that the cost of the by-pass is greater than that of of the dam.

It has been known recently that riparian owners downstream of some dams have complained that the storage of the water above them has reduced the flow in the stream, and have asked for the dams to be removed. This reduction in the flow in the streams may be due to the general lowering of the water table throughout the country during the last few years and the greater demand for water due to the production drive in the war years.

When discussing a recent paper at a meeting of this association, I remarked that the Public Works Department and Railway should have investigation departments, which would have no executive duties.

The information collected by these departments should be published and issued to the public, so that an interest in the country's development be continually maintained.

Engineers and architects should be asked to forward any data which they may collect and likely to be useful. Even if only 5 per cent of the information sent is worthy of tabulating it will not be labour wasted.

MAJOR C. RICHARDS, R.E. (MEMBER):

Dr. Parsons is to be congratulated on his able exposition on the principles of finding water.

We expected a really high standard and were not disappointed.

In the course of his address Dr. Parsons referred to the artesian water at Lumbwa. This was in a borehole drilled by my unit and the following facts may be of interest:—

(1) Altitude of borehole 7,500 ft. approximately above sea level.

(2) Flow 250 gallons per minute. Time of year: May.

The driller reported a week before the water was struck that the Mother Superior at the Convent had dropped some Holy Water down the hole!

I would also like to record the opinion on dowsers as expressed by Chief Engineer of Australian Forces in Mid-East in May, 1944. These forces had spent three to four years in Mid-East and were mainly concerned with finding water supplies in the Western Desert. The following is a verbatim quotation from an official report which adds: "Similar successes have been obtained by geologists in South-West Pacific Area":—

"Our experience has been without one shadow of doubt, that the water diviners' assistance has been absolutely worthless. Not only is their percentage of successes below what would have been expected by mere chance, but their ability to distinguish between saline and non-saline water does not exist. They have been given a fair trial and we have come to the conclusion that they should be prohibited from even offering gratuitious advice.

We have had an enormous amount of assistance from our geologists, who in my opinion are experts, and we have had quite remarkable results from the geophysical earth resistivity measurements of our geological sections."

Personally as one with whom the dowsing rod works, I would say I would just as soon believe that a few drops of Holy Water produced an artesian well as that the dowsing rod indicates water or anything else.

MR. F. GRUNDY (VISITOR):

Dr. Parsons has given an interesting outline of some branches of hydrology, a science which has made rapid progress in recent years as a result of organized investigation in various countries, in some of which extensive experiments in field and laboratory are now in progress.

The hydrologist is particularly interested in that part of the hydrologic cycle which relates to the disposal of rainfall and I hope I may be allowed to make a brief reference to this subject. I shall use the term rainfall to include all aqueous deposits derived from the atmosphere, in conformity with British practice.

Rain falling on land surfaces covered with vegetation does not all reach the soil; much of it is intercepted on leaves, twigs, etc., and subsequently evaporated. In dense forest with heavy undergrowth this loss may amount to over 25 per cent of the total rainfall in a year.

Of that rain which does reach the soil, some runs over the surface into depressions and stream channels, and some enters the soil; the proportion into which the rain is so divided varies with numerous factors, of which the intensity and duration of the rainfall, the infiltration rate of the soil surface, the percolation rate of the soils and rocks below the surface and the extent to which the soil has been previously depleted of moisture by evaporation and transpiration, are among the more important.

Water entering the soil has first to restore the soil reserve of moisture to the field capacity of the soil throughout the depth depleted of moisture by evaporation and transpiration. Should rain continue, further water entering the soil can percolate to the ground-water table and become available for providing flow from springs and into wells.

In dense forest, evaporation from the soil surface is small in amount, but the vegetation takes a heavy toll of rainfall by interception and transpiration, amounting in some cases to over 90 per cent of the annual rainfall. This enormous discharge of moisture into the atmosphere, which in places like the Mau Forest may be equal to a flow of 3 cusecs per square mile, is now the subject of close investigation in America, Russia and other countries. The decline in rainfall in many parts of the world during recent years combined with the growing demands on ground water and the depletion of ground-water supplies, has directed inquiry to the possibility of reducing the large losses of moisture to the atmosphere by manipulating the vegetative cover of recharge areas of ground-water reservoirs and introducing vegetation which, while not appreciably increasing surface run-off or erosion, will increase replenishment of ground-water.

Dr. Parsons has drawn attention to the difficulty of measuring evaporation. The hydrologist is interested in evaporation from both land and water surfaces, but it is the latter which concerns the design of reservoirs and canals and which is generally termed evaporation from a free water surface. Various types of evaporimeters are in use for measuring evaporation and it is of the utmost importance to know whether a coefficient has been applied to the recorded evaporation. The evaporation at Wadi Haifa in Egypt is frequently quoted in text books as nearly 20 feet per annum, sometimes without reference to the fact that this evaporation has been recorded by a Piché

instrument; the equivalent evaporation from a free water-surface, as investigated by the Sudan Irrigation Service, is only about 10 feet depth of water per annum, i.e. a coefficient of 0.5 has to be applied to the instrument records.

The assessment of the run-off or yield of catchment area still presents great difficulties in spite of the mass of literature and the 60 or more formulae relating to its calculation. There is one, and only one, way to be reasonably certain of the yield and that is to gauge the run-off over a considerable number of years; and even then, a change in the cycle of rainfall or denudation of the catchment area by uncontrolled cultivation may wreck an impounding scheme by unpredictable drought, floods or silting.

Dr. Parsons has stated that "it is estimated that in England about 50 per cent of the rainfall is lost by evaporation, 25 per cent by run-off and 25 per cent by infiltration". Surely infiltration, i.e. water entering the soil, is disposed of partly by evaporation and transpiration and partly by ground-water run-off? According to the Surface Water Year Book of Great Britain for 1936–1937, the yield of large catchment areas such as the Thames and the Severn for that water year was about 50 per cent of the rainfall, the balance being returned to the atmosphere.

Again, it is stated that "In tropical countries especially those with pronounced and heavy rainy seasons a very large proportion (of rainfall) is lost by run-off". This general statement requires qualification when applied to many areas in Kenya, where, although our information is still scanty, it is known that run-off is seldom over 20 per cent of the rainfall and sometimes less than 10 per cent. Similar figures are available for catchments in the Gold Coast covered with dense forest and having about 60 inches annual rainfall.

Reference has been made to the effect of aquatic vegetation on evaporation from reservoirs. In the *East African Agricultural Journal* of September, 1935, there are reported the results of laboratory experiments made at Amani Research Station. Four types of such vegetation were used and in each case it was found that water surfaces covered with vegetation lost more water than open surfaces, the worst offender being the water lettuce, which increased evaporation by 25 per cent. Information on this subject is very limited and in reply to many farmers and others who have asked me for advice, I have accepted the results of the above-quoted experiments, and advised the removal of all vegetation from water surfaces. Dr. Parsons, however, apparently disagrees with the findings at Amani, and in view of the wide interest in this subject, perhaps he would kindly tell us more about it.

MR. O. SOSKICE (MEMBER):

May I first of all congratulate Dr. Parsons on a most excellent and instructive paper. The subject has been presented with the greatest clarity, which makes the paper most interesting for those who, like myself, are not specialists on this subject.

There are three questions I should like to ask Dr. Parsons:—

(1) The most common types of tree which one sees planted in the Highlands of Kenya are gum, wattle and *Grevillea*. Are these necessarily the best, from the point of view of soil erosion and of providing good ground storage and soil sponges which preserve the perennial flow of streams and springs? One gathers from the paper that gum and wattle exercise a desiccating effect on the soil.

(2) Can Dr. Parsons give any indication of the percentage success of geophysical surveys in locating water supply? I have seen four surveys by the resistivity method for locating ore-bodies. One of these located a massive lead-zinc ore-body, which could not have been readily found by any other means. The other three could be classed as failures.

This percentage of success in locating mineral deposits could certainly be classed as high and makes the method economically worth-while. In location of water supplies, however, does not the expense and uncertainty of geophysical survey make this method an unpractical proposition, at any rate for the individual? Another point is that I should have thought the restivity methods of survey would have tended to favour the location of bodies of ground water, highly charged with mineral content in solution, and, as such, unsuitable for normal use.

(3) I have only seen one demonstration of dowsing for quartz veins, and was not very impressed. Can Dr. Parsons give any example of mineral deposits actually discovered by this means? Was the quartz reef that he mentions in his paper actually located in the first place by dowsing, or had some work already been done on it when the dowser mapped it?

MR. D. HARVERSON (MEMBER):

Have you any data as to the time lag of the Kikuyu Springs that feed Nairobi water supply (i.e. how long elapses after good rains before the springs increase their flow)?

Can you give any description of the method whereby "occult precipitation" is measured? Presumably the amount deposited depends largely on the nature of the collecting surfaces. What are the standard material and texture, etc.? I take it that "occult precipitation" covers the phenomenon known in ordinary non-scientific life as "dew".

Have there been any attempts at making dew-ponds in East Africa, and if so what success have they achieved? Can you give any figures as to the collecting powers of successful dew-ponds in England or elsewhere?

MR. RAWLINS (VISITOR):

The Land and Agricultural Departments consider Thika, Mitubiri and Makuyu "dry areas". Although rainfall is not very much when compared to other parts of Kenya, how would you account for one sisal estate which has a dam served by several springs giving adequate water supply for machinery to deal with 1,000 acres of good sisal. They have never found it necessary to use the Thika River which is some 600 yards from the factory as the dam has a good water supply all the year round.

Do you think that "water boring" has any ill effects on dams and natural springs in various parts of the country? I have heard many comments regarding this and would like your views please.

MR. P. V. CHANCE (MEMBER):

I have read Dr. Parsons paper with great interest and, while I am not competent to discuss the geological aspect, I may perhaps comment on the hydraulic problems.

Rainfall.—It has recently been stated that the rain gauges in the Aberdares are inadequate and badly sited; they always are inadequate and badly sited not only in Kenya but in every country. The three largest reservoirs in the Central Provinces of India with catchments of 430, 313 and 278 square miles had no gauges in their areas before work was started and the rainfall had to be estimated by interpolation from adjoining gauges. Deakin, writing of English reservoirs, remarks that: "If any observations exist upon the drainage area, they are commonly only from a single gauge, and this, unless the area is very level, may give results widely different from the mean fall on the whole area".

Dr. Parsons has pointed out the variation in recorded rainfall on a limited area near Moshi. In England fourteen gauges erected in a row showed 20 per cent difference in gauges only 70 feet apart and 30 per cent in gauges 560 feet apart, and these differences were consistent over a number of years; this shows the difficulty of obtaining a really accurate figure for the total rainfall of any extensive area, more especially in hilly country.

Run-off.—There are many formulae and tables, pretending to considerable accuracy, for determining the percentage run-off for a given rainfall. Sir Alexander Binnie's percentages have been calculated to three decimal places, but records of actual run-offs show how widely inaccurate such formulae or table may be.

The author has mentioned a case in which a reservoir filled with 19 cm. annual rainfall and was empty with 25 cm., and such bewildering results are not uncommon. I had the percentage run-off plotted against the rainfall for 20 large reservoirs in India, and each plotted sheet looked like if a shot gun had been fired at it; it is true that there was a tendency for the run-off to rise with the rainfall, but it was no more than a tendency. I give the following figures to illustrate this point:—

Country	Reservoir or River	Catchment sq. miles	Annual Rainfall Inches	Percentage Run-off
India	Shirsipal	23.5	15.3	21.9
,,	,,	23.5	15.3	81.8
,,	Mhaswad	480	16.8	7.7
,,	,,	480	16.0	46.7
America	Sweet Water	186	16.52	12.5
,,	,, ,,	186	16.19	45.7
Spain	Guadalquiver	5875	24.9	47
,,	,,	5875	23.0	9

Such figures could be multiplied indefinitely and show that, even with the same geological and physical conditions, the run-off may vary widely for the same recorded rainfall, more especially in areas of low annual precipitation. How far this is due to insufficient rain gauges it is difficult to tell, but certainly much of the difference is due to varying daily and even hourly intensities of precipitation. A fall of six inches in one day will produce much greater run-off than a similar fall spread over a month, and this most records fail to show. If they do show it, it may not be of much use in calculating future run-offs.

Evaporation.—Major Grundy has mentioned most of the points I wished to raise. I entirely agree with him as to the importance of knowing the method of measurement and the factor, if any, which has been applied. The following figures recorded from Croydon may be of interest:—

Average evaporation over 13 years from 12 in. evaporation floating in water: 19.95 inches.

Average evaporation over 13 years from 5 in. evaporation in air: 38.18 inches.

Dr. Parsons has pointed out the importance of collecting and recording information, and with this every engineer will agree; I would, however, bear testimony to the great amount of work in this connexion, which has been done by the Hydraulic Branch of the Kenya Public Works Department in recent years. What surprises me is that they have been able to collect so much and such useful information in the short time available, and often in the face of considerable difficulty.

In conclusion I would thank Dr. Parsons for his most interesting paper.

MR. A. E. TETLEY (MEMBER):

Except possibly in some comparatively small, fortunate areas Dr. Parsons may rest assured that he will never have to apologise for talking about water in Africa where the call will be for more and yet more water. I am sorry that Dr. Parsons has treated the subject so largely from the academic side and has not drawn more on his own practical experience but even so in the present stage of our association the paper is very welcome indeed.

There is evidently a misprint in the paper as the lowest annual rainfall recorded at Mombasa occurred in 1898 and the highest in 1922.

In dealing with rainfall it is, I think, unfortunate that Dr. Parsons has not considered the full rainfall records available. This is particularly so as, at the end of last century, there were only three rainfall stations in this Colony, and Mr. Lewis' report was published in 1925 and therefore presumably contains rainfall statistics until the end of 1924 only. In dealing with the highest and lowest annual rainfalls at Machakos long-term station, these are 58.32 in. and 15.92 in., respectively, whilst in Nairobi, taking the "Hill" station, the figures are 58.88 and 17.63 inches respectively. None of the above-mentioned stations reflects the really enormous variations which are experienced in our annual rainfalls. In this respect Binnes' classical analyses of annual rainfalls do not hold in most of Africa. For pride of place in this respect locally it is only necessary to consider Makindu with an average annual rainfall over a period of 34 years, of over 24.7 inches, with the lowest annual rainfall over one, two and three consecutive years of 10 per cent, 34 per cent and 39 per cent respectively of the mean rainfall. Further it has a period of six continuous years when the annual rainfall was below the mean and during which period it averaged 72 per cent of the mean. The highest rainfalls for one, two and three consecutive years are 312, 237 and 209 per cent of the mean.

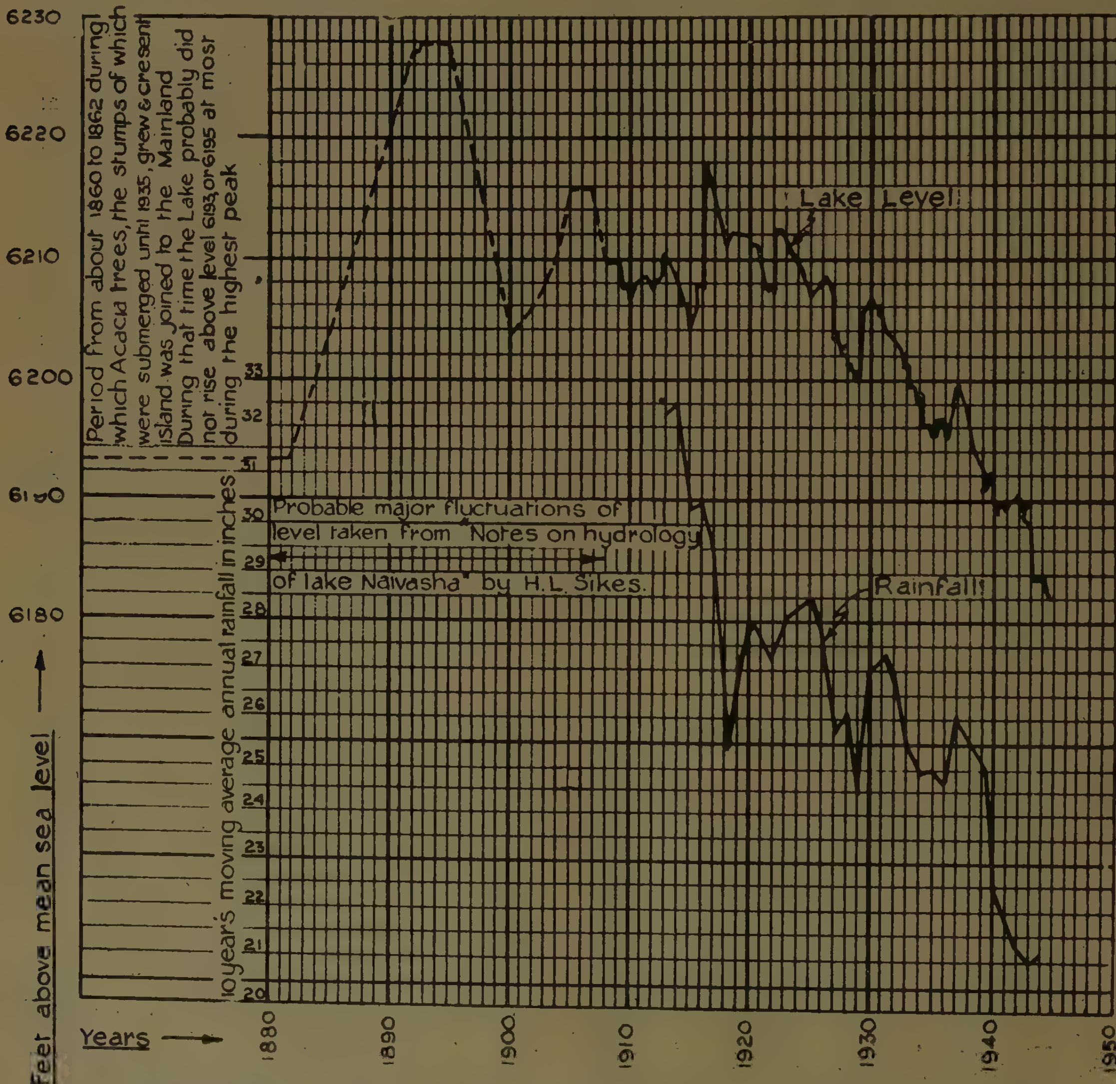
Even on the coast large variations are experienced, e.g. at Kilifi, with an average annual rainfall of 36.8 in. over 26 years, the lowest recorded annual rainfall has been only 9.54 in. When it comes to average annual rainfalls I consider that the maximum deviation from the mean in dry years should always be quoted simultaneously. It would assist greatly in getting rid of the "humid mind" complex in those people who will talk in terms of average annual rainfall which, in most of Africa, is an entirely meaningless term so far as hydrology is concerned.

Whilst Dr. Parsons has mentioned somewhat casually the annual distribution of our rainfall he has not stressed that one of the reasons for our poor water supplies is of course the fact that over much of Kenya our rainfall occurs in two short, erratic rainfall seasons and even in those seasons it is sporadic and the catchment often dries up between falls of rain. Usually, depending on the catchment, it takes about eight or more inches of fairly continuous rainfall in a season before we get run-off established—depending of course also to some extent on the incidence of the rainfall. If our annual rainfall fell in one season, then we would get far more run-off and it would be more certain in its occurrence. Further, if it fell in one season, we would get far greater recharge of our ground-water reservoirs, because, at the beginning of each dry season, the first call on the precipitation which reaches the ground is to replenish the deficiency in the soil moisture. This demand is heavy locally, due to the prevailing high temperature, high insolation and the consequent high total evaporation and it is only in very good rainfall seasons that there is generally sufficient residual moisture to afford effective recharge of our ground-water reservoirs.

Dr. Parsons has said: "In the appraising of any water scheme, it follows that not only is it necessary to study the rainfall figures, but all its characters and variations should be studied in so far as they affect the catchment area". And again: "A study of all the data available would appear to show that East Africa is not so much an area of decreasing rainfall, but rather suffering from increased and unhampered run-off, largely due to wanton destruction of vegetation, which in the past have protected the soils".

I would go further and state, any factor affecting our climate and run-off must be considered. Perhaps I may illustrate my argument by referring to Lake Naivasha. We hear about decreasing rainfalls, droughts, deteriorating stream-flows, the drying up of springs and various other phenomena. But what are the standards by which they are judged?

Rainfall records in the Colony are unfortunately all too short—as I have already said there are only three rainfall stations in Kenya with continuous records extending into last



VARIATIONS OF LEVEL OF LAKE NAIVASHA AND 10 YEARS MOVING AVERAGE ANNUAL RAINFALL

century—so let us turn to the other evidence of climatic conditions available, Lake Naivasha, which we all know, occupies the lowest part of its drainage area. It is an enclosed lake and is therefore a good index of climatic variations to which the area is subject. The lake covers a fairly large area and may attain considerable depth during a series of years of more than average rainfall, but it becomes depleted (as we all have seen) in periods of deficient supply. The level of the lake reflects the balance between the inflow on the one hand and losses due to evaporation, transpiration and seepage on the other. The seepage loss, I may state, appears to be about six inches to 10 inches depth per annum, which is comparatively small. The available evidence from the remains of an upright tree trunk indicates that, for a period of at *least* 20 years before 1882 the *highest level*, I repeat, the *highest level*, of the lake was only about 11 feet above its present level. The figure shows the variations of lake level and also the ten-year moving average annual rainfall of Naivasha.

In connexion with this period of 20 years prior to 1882 I recently came across the following extract from a paper by Mr. J. F. Wilson entitled "The Water Supply of the Orange River Basin," published in the Transactions of the Royal Geographical Society in 1865. "During the year 1862 an unexampled and very widely developed drought prevailed though the Cape Colony and made itself felt far into the tropical regions in the neighbourhood even of the Great Lakes."

What the lowest level of Lake Naivasha during that long low period was I do not know, but there are reports that there are still some more small trees appearing from below the surface of the lake as it continues to fall. As the maximum depth of water in the lake at present, excluding that in a small crater, is only about 12 feet and that over a very small area, possibly the lake dried up completely or was reduced to a series of small pools. The low period I have mentioned, apparently stopped about 1882, from which year to 1894 or 1895 the level rose above the high peak of the long low period by about 35 feet. The lake reached its next highest peak in 1917 when the level was about ten feet below the 1894-95 peak. Since that year, i.e. 1917, the lake has dropped about 36 feet in level, its area has shrunk from 86 square miles to about 36 square miles and it has lost more than seven-eighths of its water —all in less than 28 years. I think that it is quite safe to say that during the low period ending about 1882 there were no diversions from the tributary area or that the catchment area generally was not overstocked, overgrazed or even cultivated to any extent. Yet, in spite of these facts, Lake Navasha was lower than it is to-day and was probably so for a very long period. The average run-off necessary to support the rapid rise from about 1882 and the generally high stages from about 1892 to say 1917 was materially larger than it has been since 1917. I would also mention that in Lakes Baringo and Rudolf, dead tree stumps at about the same comparative level as those in Lake Naivasha have been found and that from recent evidence they are still appearing.

It, therefore, appears that the fluctuations in level of these lakes were due to common climatic cause and that the water-supply conditions at the end of last century and the beginning of the present one, were, in general, much better than they have been since 1917. As white settlement started during the latter part of this favourable period or at least, before the effects of the less favourable period were felt—it is clear that early estimates and ideas of water-supply conditions were more generous than the recent less favourable period can justify and that it is necessary to re-adjust our ideas on this vital matter. Whilst a series of good rainfall years may begin at any time, in my opinion, the view should be taken that the trend is more towards drier conditions. In any case, if we work on this basis we won't be disappointed. Further, the sporadic fluctuations in climate are lucidly indicated by history and should not be forgotten.

It may be of interest to turn to enclosed lakes in America. In the western parts of the Great Basin the lakes there show an upward trend from about 1860 to 1915, when the water levels reached were higher than they had reached in the preceding 200 years. It is also worthy of note that since about 1850 glaciers generally throughout the world have been retreating and shrinking, but since about 1920 they have been receding at an accelerated rate. Recent articles in the *East African Standard* also refer to the retreat of glaciers on Kilimanjaro and those who have known Mount Kenya over a long period also state that the glaciers on that mountain are also shrinking.

Even in the more fortunate parts of Kenya, the difference between precipitation and total evaporation (which term includes transpiration) is small, so that as soon as a drought or a series of years of poor rainfall occurs there is normally little, if any, water available for recharging the ground-water reservoirs (from

which our streams derive their dry weather flows), and the water-table naturally drops. The higher seeps and springs dry first and the discharge of the lower springs tends to decrease. In general, ground water is the last to reflect drought effects so that when we enter a less favourable period, caused by lower rainfalls and/or higher temperatures, we do not feel the effects on our streams immediately. In comparison with the favourable period towards the end of the last, and the beginning of this, century, the level of the ground water tables practically everywhere in Kenya must have dropped considerably as reflected in the diminishing dry-weather flows of our streams, our falling lake levels, the drying up of swamps and the shortening of our tapering streams. When we again enter a more favourable period, the ground-water table will take a very long time to recover; that is why, when we do have a fairly good rainfall season following a drought, our rivers do not recover their former dry-weather flows immediately.

I mentioned just now that the less favourable period may be caused by lowering rainfalls and/or higher temperatures. While the ten-year moving average of the rainfall at Naivasha shows a generally falling trend since the start of the records, I cannot give you any temperature records in Kenya. However, although it is a long way off, the average temperatures in both winter and summer at Helwan Observatory in Egypt show that during the period 1923-42 average temperatures have risen by 1° F. in both cases compared with the period 1903 to 1922.

Dr. Parsons has remarked: "Some aver that forests rather than conserving water supplies dissipate them by their action in draining the soil, as well as by transpiration from their leaves. On the other hand others insist that they (forests) are an important factor for increasing supplies, by decreasing run-off, as well as by the chilling of the atmosphere by evaporation from the foliage and thus assisting precipitation." It has also been stated that dams increase transpiration and humidity of the atmosphere and doubtless further increase precipitation.

Whenever there are periods of deficient rainfall attention is focused on alleged methods for increasing local rainfall and altering our climate. These methods include decreasing cultivation, and other recommendations are the impounding of run-off in lakes and ponds, the increasing of cultivation and the planting of crops and trees which have high transpiration rates. There is no question that continental evaporation adds large and significant quantities of moisture to the atmosphere. In fact, taking a world-wide figure, it is about 75 per cent of the continental rainfall, while in Kenya it is probably more than 95 per cent. It is a popular fallacy that there is a direct relationship between the amount of precipitation in an area and the amount of moisture in the atmosphere. However, the process of precipitating atmospheric moisture is known to depend on several variables and no simple procedure involving solely an increase in atmospheric moisture can be expected to increase local or other rainfall. Recent studies in America of the upper atmosphere by the use of instruments attached to planes and by means of radio, have proved that the absolute quantity of water in the atmosphere has no immediate relation to the quantity of rainfall any given climatic region may receive. Climatic regions, whether arid or humid, belong to their respective categories, not because of the availability of moisture, but *primarily* because of their positions on the face of the globe with respect to the atmospheric circulation system. Precipitation is beyond the control of man and there is not the slightest evidence that he can influence it even in the slightest practical degree, either for better or for worse.

Dr. Parsons has mentioned that: "The relatively flat lands of the 'Nyika' from 40-50 miles inland to the rise of the highlands heat up these currents by convection. Consequently instead of precipitating further rains they dry up the country and give rise to semi-desert conditions. This type of country stretches throughout Kenya and southwards into Tanganyika." A few figures are worth quoting. Take Samburu station (only 40 miles by rail from the coast) with an average annual rainfall of 21.3 inches over 15 years. The following drought periods have been experienced. Over 12 continuous months 0.1 inches, over 19 continuous months 1.3 inches, over 33 continuous months 2.5 inches, over 36 continuous months 5.4 inches total rainfall.

I think that the example of the borehole at Mitubiri is rather unfortunately framed. To the layman, it might well read as if the only successful positions in which to sink boreholes in areas where the gneissic foundation is blanketed by volcanic formations, is on the tops of ridges, and that the edges of swamps are definitely not places in which to sink boreholes. Furthermore, it gives the impression (all too common among people in this coun-

try) that the all-important factor is to find a site where water may be gravitated to where it is wanted. A case such as that quoted is, in fact, only one special instance and while it is admitted that finding the old river channels now concealed beneath the mantle of volcanic rocks may well result in a higher yield of water, it is by no means the only type of position beneath volcanics in which water may be found, or, for that matter, water in large quantities.

Reference page 16. As a point of interest I may mention that both magnetometric and electrical methods of geophysical investigation are used locally in the selection of borehole sites. The use of these methods has increased the percentage of successful boreholes locally by 11.5 per cent approximately, i.e. from 66 to 77.5 per cent.

Reference page 16, col. 2. To which grits does the author refer? The Shimba Grit or the Taru Grit? It may be interesting in either case, to mention the facts, that only one borehole has even been sunk in the Taru Grit and that, as far as reports go to show, it struck no water whatever down to a depth of 1,340 feet. This was an exploratory drilling in search of coal, some two miles and a quarter west of Samburu Station and close to and on the north side of the railway line. Similarly, little or no water has been obtained from the Shimba Grit in the Shimba Hills by boring. Four boreholes sunk near Mrere and one at Kwale, obtained their water from the Mazeras Sandstone Series or from detrital material lying on this series. Another point is that the water in the four boreholes near Mrere had a moderately high degree of salinity. This merely confirmed the results of electrical resistivity tests in this area where apparent resistivity values over a range in depth of 400 feet produces values as low as 160 ohm/cms.

MR. J. SCOTT (MEMBER):

Dr. Parsons is to be congratulated on having produced a paper which re-examines the fundamentals of finding underground water. Water is not exactly easy to find in Kenya. When you know the geology of the country, and know the structure of the district you are in, and the tectonics which produced that structure; and avail yourself of every aid that geophysics can give you, you will still get one failure in every four or five boreholes.

The steam jets on Eburru. Joseph Thomson, who first discovered these steam jets late in 1883, says this of them:—

"The conclusion that I arrived at after examining the ground was that the steam had not a deep-seated source, but was simply originated by water percolating into the lava current on which we stood, that lava having been so lately ejected that it had not as yet cooled down."

I have looked fairly carefully at these steam jets and see no reason to doubt Joseph Thomson's interpretation of them. Mr. Mardon, on whose farm most of the steam jets occur, and who condenses them for his water supply, told me that in a prolonged drought the steam gets less and less. It requires a shower of rain to bring up the yield again.

Another line of evidence that the steam originates in the rain that falls on the lava flow is to be seen in the condensers they use. They are all made of galvanized iron. Mr. Mardon showed me some of these condensers put in by Mr. Harvey ten years before he bought the farm. They were still in good order, though they were only 24-gauge. If steam jets come from a magma, or from anywhere deep in the earth they usually bring up very corrosive gases with them—sulphurous and sulphuric acids, boric acid, and gaseous sulphur. These would destroy 24-gauge galvanized iron in a few hours. Yet these condensers were still in use after 17 years. The evidence seems pretty strong that they are condensing only pure distilled water.

It is a continuous surprise to me how well boreholes maintain their yields in this country. I suppose it is because they are few in proportion to the capacities of the aquifers that supply them. There are one or two exceptions. The boreholes along the railway ridge, from Nairobi to Kikuyu, are falling off with the present drought. That aquifer is probably being overworked. It is a perched aquifer and strictly limited in both width and depth. There are many boreholes along it, and the two municipal ones at least are being pumped to capacity. Probably some of the others are. With normal rains they will no doubt pick up again. Around Machakos there are a few boreholes which fall off in droughts. But probably about 95 per cent of all the boreholes in Kenya never vary at all.

Geophysical aids: I am sorry Dr. Parsons has not said more on this subject. It is the most important development that has ever been made in the science of water finding. The resistivity method, with empirical interpretation of the curves, has been used now for several years by the P.W.D. It does not tell directly whether there is water down below or not. It measures the average specific resistance of the earth down to any required depth. If

the stuff is wet and soft the resistance is low, if it is dry or hard the resistance is high. Of course one must know enough of the geology to know what is down below. Otherwise you might as well use a twig or one of the much-advertised water-finding machines.

The use of the resistivity test has brought up the overall percentage of successful boreholes from around 66 per cent to between 75 per cent and 80 per cent. When you reckon that the average borehole in Kenya costs over £400 to drill, it can be seen that there is a saving of roughly £5,000 on every 100 holes drilled.

On what evidence does the author rely in saying that water is invariably found at the contact of the volcanics with the gneissic floor? I do not know of any borehole in Kenya which has found a good supply at that junction, and there are several which have passed through it and found none, or too little to be worth bothering about. As for the major valleys in the old gneissic floor, there is a very good one under the Yatta Plateau. It is the old bed of the Athi, a river which in pre-Rift Valley times had a much larger drainage area than it has now. But I have seen no springs coming from it. There are no boreholes that I know of on the Yatta, but I would be doubtful if boreholes there would find water.

Is the author quite certain the borehole at Mitubiri found its water in an old gneissic valley? I presume he is referring to Mr. Torr's borehole. The best aquifer in that area is in the beds overlying the Kapiti Phonolite. The two very good boreholes on Sisal, Limited, at Makuyu get their water from that aquifer. The driller's log for Mr. Torr's borehole shows the same series of beds, with no mention of gneiss at the bottom.

The objection of the volcanic-gneiss contact as an aquifer is that the first lavas extruded in this country were fissure eruptions of phonolite which flooded the old gneissic topography with very liquid sheets of phonolite, probably at very high temperatures. These phonolites are all very impervious. They cover the whole of the Athi plains beyond Athi River, and probably underlie the lake beds on this side of the Athi. They extend northwards as far as the Maragua-Tana power station, and probably further. Another lot of phonolites cover all northern Laikipia and most of southern Laikipia. They extend right across the Rift to the Uasin Gishu, where they cover enormous areas. They are so tight that water cannot readily get through them into the gneissic contact. This theory (like all good theories) was evolved after it was found by experience that drilling into this contact gave disappointing results.

The best aquifers in the volcanics of Kenya lie on top of these phonolites. The following period of vulcanism gave rise to enormous quantities of volcanic agglomerate and ash—the Aberdares, for example. These are the beds in which every good borehole up the east side of the Aberdares, from Nairobi to Nyeri, gets its water. They are very porous, and the phonolite pavement below them prevents the water passing down to uneconomic depths.

Dr. Parsons' Reply:

I must thank members for the very complimentary remarks and reception of my paper. A paper of this type must of necessity be largely a matter of scissors and paste. It is gratifying to learn that I have not succeeded in cutting myself to ribbons with the former and gumming myself up with the latter.

Mr. Pollok has raised two points from the Kanthack Report, which has been published since my paper was read. I am glad he has done so as it gives me an opportunity to refer to that report. As Mr. Pollok rightly remarks this is an extreme case of the importance of geological studies in the matter of water supply.

It must be a source of satisfaction to members of this association to have confirmed what they already knew, but which apparently was not known to the Kenya Government, that there is no need to import personnel from U.S.A. or elsewhere to find a solution to our problems. We have men on the spot better able than imported products to solve our troubles. I think that this association should regard it as a duty to discuss Mr. Kanthack's report. It is a duty of each one of us as engineers and residents in East Africa to offer some solution to the very serious water problems that confront us, and which some of us have the temerity to believe we can at least alleviate. President Hoover in his text-book of mining makes a great point of the fact that to the engineer nothing is impossible, though it may be prohibitive.

Mr. Pollok very rightly points out that there are storage schemes which have proved practicable in the Western Ghats, where geological conditions are similar to those of this country. If it can be done there why not here?

With reference to Mr. Marriott's remark quoted by Mr. Pollok, one must agree with this, but with reservations. Provided the rocks are sedimentary, and that they have been carefully studied and mapped in great detail, there is no reason why a geologist should not be able to guarantee a well or borehole site.

Mr. Pollok's remarks on the subject of run-off are of great interest. In this connexion in refutation of the remark in Dr. Kanthack's report, it may be pointed out that the graphs of the gaugings in the Tana River, taken regularly by the East Africa Power and Lighting, show not only marked increase in the run-off during the short rains, but even most markedly the effect of the intermittent rains we have experienced during July and August of this year. This would indicate the danger of applying rule of thumb methods.

I am sure we all endorse Mr. Pollok's desire that the P.W.D. and the Railway should publish facts and data their work discloses. We have had this evening two examples of the value of such in the contributions of Messrs. Tetley and Scott. To these two departments I would like to add the Mining Department, which seems particularly loath to disclose any data.

Mr. Harverson has raised some interesting points. Regarding the time lag of the Kikuyu springs after the rain, I have asked Mr. Lochead, the Municipal Water Engineer, and he tells me that it is usually three months, the October-November rains not causing an increase until about the following February.

Occult precipitation does include dew. In the case of the Lindi figures given in the text of the paper, the medium used was corrugated iron sheeting. Condensation of dew on this was measured daily over a protracted period in arriving at the figures. As to the means of measuring the condensation in the sand dunes I have no information, but provided these are situated on impermeable strata, I cannot see much difficulty in taking these measurements.

I do not know of any dewponds in East Africa. There has been considerable discussion on the importance of precipitation by these means. It is agreed that the total contribution is not large, but one school is inclined to give it more emphasis than the other. No agreement has been reached. In the case of condensation in the cracks of the black trap soils one school attributes very important contributions to the dry-weather growth.

The most important aspect of this question is undoubtedly the fact that while it is taking place, however minutely, losses by evaporation have ceased.

Mr. Rawlins asks some questions as to water supply in the Makuyu, Mitubiri and Thika districts. It is interesting to hear that the yield from the springs on the Sisal Estate is so prolific. Such yields are known to the writer to emerge in many places from the contact of the gneisses and the volcanics. Whether these particular ones do or not I cannot say without a local inspection. Mr. Scott in his contribution mentions that ash beds above the phonolites, which may or may not be present in this particular locality, are good aquifers. It may be that the supply is from that source.

I do not know the basis on which the Agricultural and Lands Departments classify their "dry areas"; doubtless in this case they have not considered underground water sources.

As to the effect of water boring on springs and dams, I quoted in the paper one classic example, the case of the London Basin, where excessive drawing of water from boreholes has lowered the water-table by at least 200 feet. If the water table falls below the horizon of the spring, such spring will run dry, as shown in diagram 1A Spring A. It is hoped that the effect of boreholes on a reservoir would be nil. Losses by percolation from reservoirs must be very low, otherwise the reservoir would be valueless as a storage. If the water-table in the surrounding country be lowered by boreholes, any such loss by percolation would tend to be increased.

We are much indebted to Mr. Grundy for the information he has given. The latest figures of evaporation losses in Great Britain are certainly astonishing. But we have learned from Mr. Chance's examples the reliance that can be placed on individual tests. Dr. Du Toit's remarks quoted in my paper should be read in conjunction with Mr. Grundy's remarks on percentage run-off.

The Amani experiments quoted by Mr. Grundy are in direct contradiction to the experience of Natal, where the water lettuce has been introduced as a means of reducing losses by evaporation. It would appear that more protracted tests should be carried out to check these widely divergent results.

Major Richards has kindly given us the data on the artesian well at Lumbwa, which we are glad to place on record. Whether the holy water or the dowsing rod be the more efficient in the locating of water must be a matter of personal preference.

Mr. Soskice asks about the comparative effects of certain trees on the ground-water. I am afraid I am not a horticulturist and cannot reply. The gum trees are well known as desiccators. Other trees too act in the same way. During the 1914-18 War the cutting of trees in the Landes district in France lowered the water-table so much that a swamp became dry land. There was a paper published in Uganda by one of the forest officers on this subject some time ago. This will give Mr. Soskice some of the information he seeks.

Messrs. Tetley and Scott have given figures of the increase in successes of their water-finding operations by the introduction of the use of geophysical methods. As Mr. Scott very rightly emphasized, these instruments, while being exceedingly useful, do not indicate water. They indicate geological and hydrological conditions, which when interpreted by the geologist or hydrologist are considerable aids to the finding of water. As regards the location of the quartz veins by dowsing, I can assure Mr. Soskice that the case in question, namely Chaussu in No. 2 Area, the geologist in charge of the development found the plan produced by dowsing of inestimable value in his work. While the auriferous occurrence had been found before the twig was used, its extent had not been determined.

Mr. Chance has made a very valuable contribution to the discussion and we are grateful for the data stressing the wide variations in rainfall gaugings. It rather discounts Dr. Kanthack's remarks on this subject in Section VIII of his report. His figures, too, on evaporation losses are no less remarkable and demonstrate with what caution any evaporation figures should be used.

We are indeed indebted to Mr. Tetley for his very enlightening contribution. This only serves to emphasize the desirability of the publication of data by the Government departments at regular intervals as mentioned by Mr. Pollok. The data on Lake Naivasha are most interesting. We all trust that Mr. Tetley is being unduly pessimistic, and that for our sins we shall have the flood we have doubtless deserved. We trust that at some future date Mr. Tetley will come forward and give us a paper on the history of Lake Naivasha.

Mr. Scott's information is also indeed very welcome. With reference to his remarks *re* the occurrence of water at the contact of the gneiss and the volcanics, I can assure him that in many localities springs occur at this horizon. I am interested to hear of the high value as aquifers of the ashes on the phonolites; in the Mitubiri-Makuyu area there is not much room for these beds especially east of the road, where I know of many springs and water findings at the contact of the two formations. With reference to his remarks on the absence of springs at this horizon near Kibwezi, doubtless this is due to the fact that between this gap and Thika most of the water at this contact has seeped out. On the Yatta Plateau near the military camp the volcanic capping is less than a mile wide and the contact is very near the upper surface of the plateau. Here springs are numerous and shallow wells sunk to the contact scarcely ever fail to yield water in the dry season.

With reference to the question of the Eburru steam jets. I cannot see why if these are due to the meteoric waters making contact with underground hot lavas, similar steam jets are not also found on Longonot and Lengai, where evidences of more recent vulcanicity are more rife. I suggest that the Government departments carry out some research to determine if there be any connexion between these steam jets and the waters of Lake Naivasha; the occurrence of steam jets on the Eburru side of Lake Naivasha and of hot springs in the Njorowa Gorge suggest a possible relationship.

We are pleased to hear that the boreholes in Kenya show little or no tendency to diminish in yield provided they are not over-pumped. My experience with the gneissic rocks is that the planes of foliation are generally so tight that they are to all intents and purposes impermeable. I am more inclined to attribute the water-bearing properties of the gneissic rocks to the presence of fractures and jointing. This is in line too with the opinion of geologists in South Africa. I experienced one case in which a borehole was giving a very diminished yield, and this was found to be due to the weathering of richly ferruginous schists breaking down to a limonitic clay. Every time the well was cleaned this clay was plastered over the sides of the well and sealed off the water-bearing strata at that horizon. Only reaming of the hole could provide a cure, which could again be only temporary.

The occurrence of saline water in the coastal belt was found by the writer many years ago to be characteristic of water from the major fault planes. Contrary to the common belief the extent of igneous intrusions in the coastal belt is widespread and I can only attribute this salinity to the presence of plutonic waters in such faults.